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REPORT TO
INTERNATIONAL JOINT COMMISSION
ON
NAVIGATION AND POWER
IN THE
ST. LAWRENCE RIVER
BY
HUGH L. COOPER & CO.

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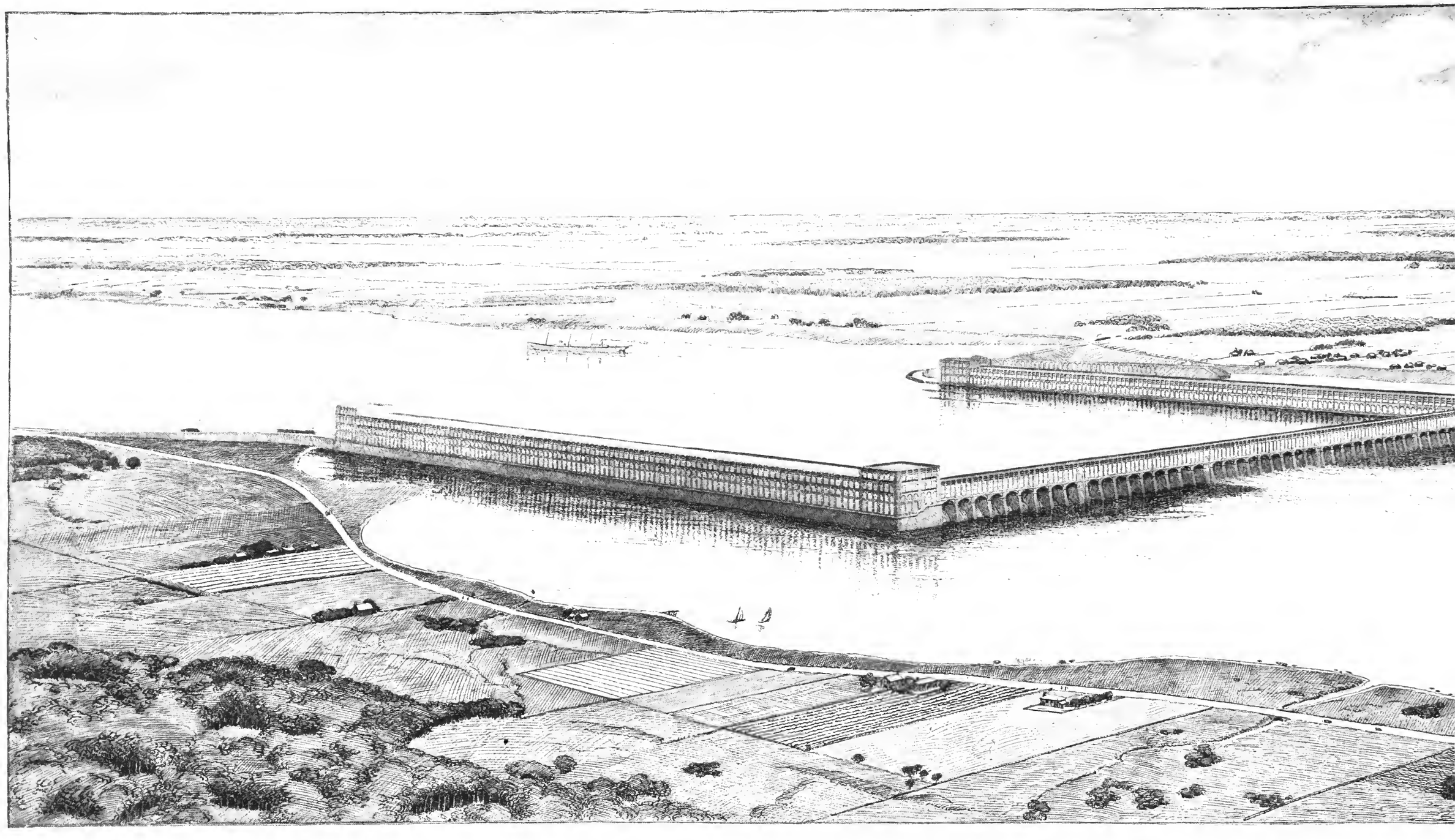
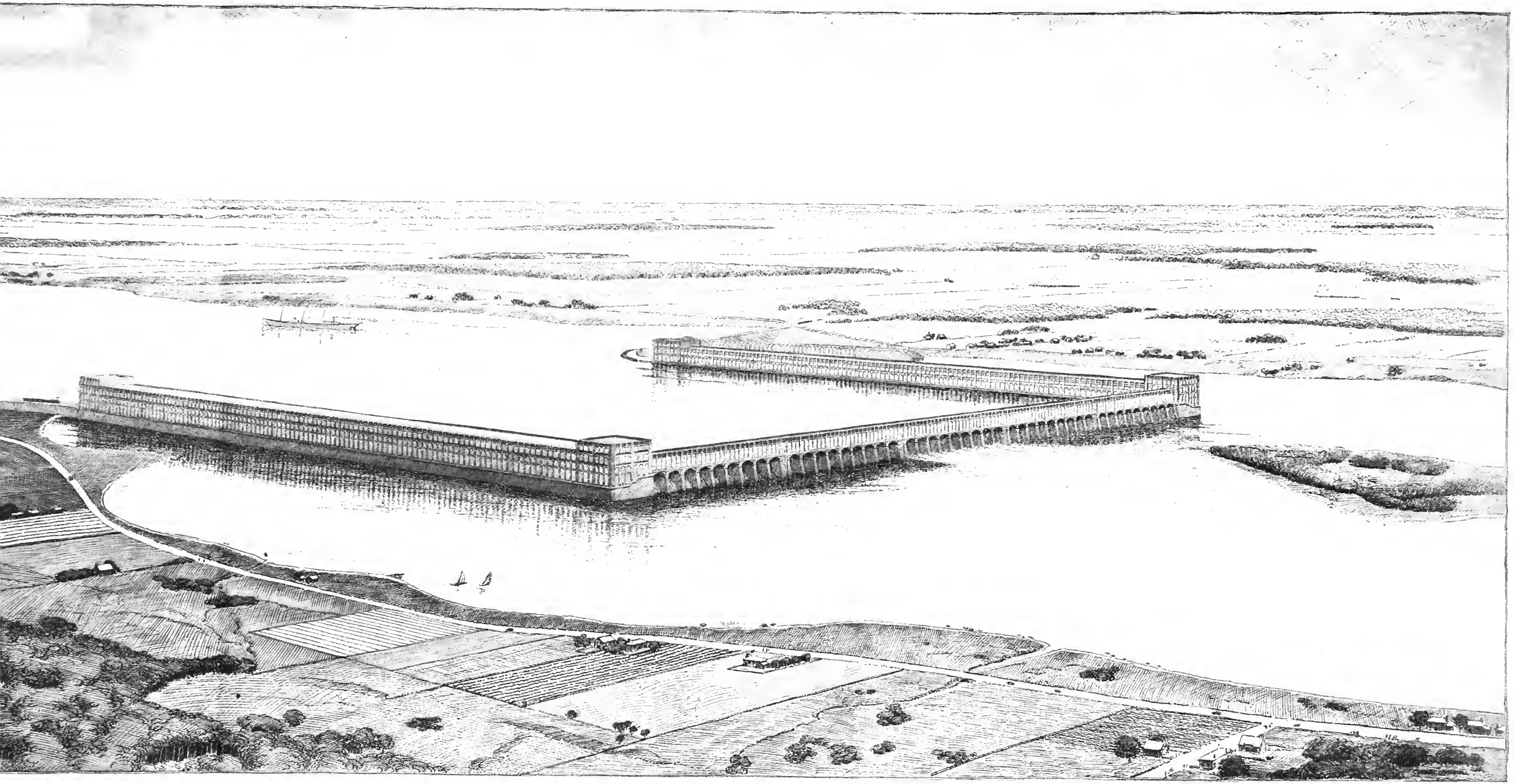


VIEW OF CROIL ISLAND PROJECT FROM AMERICAN SHORE



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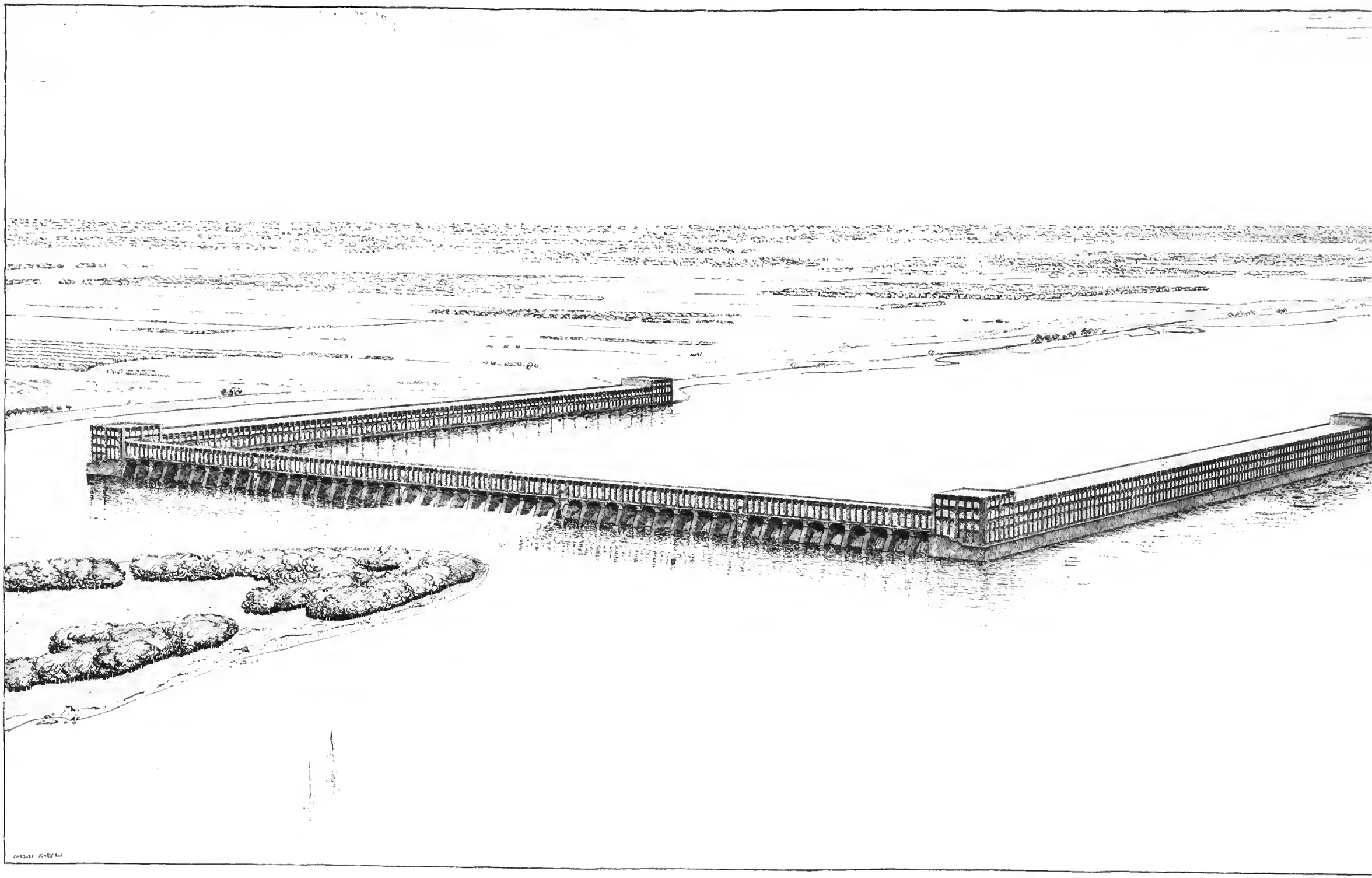
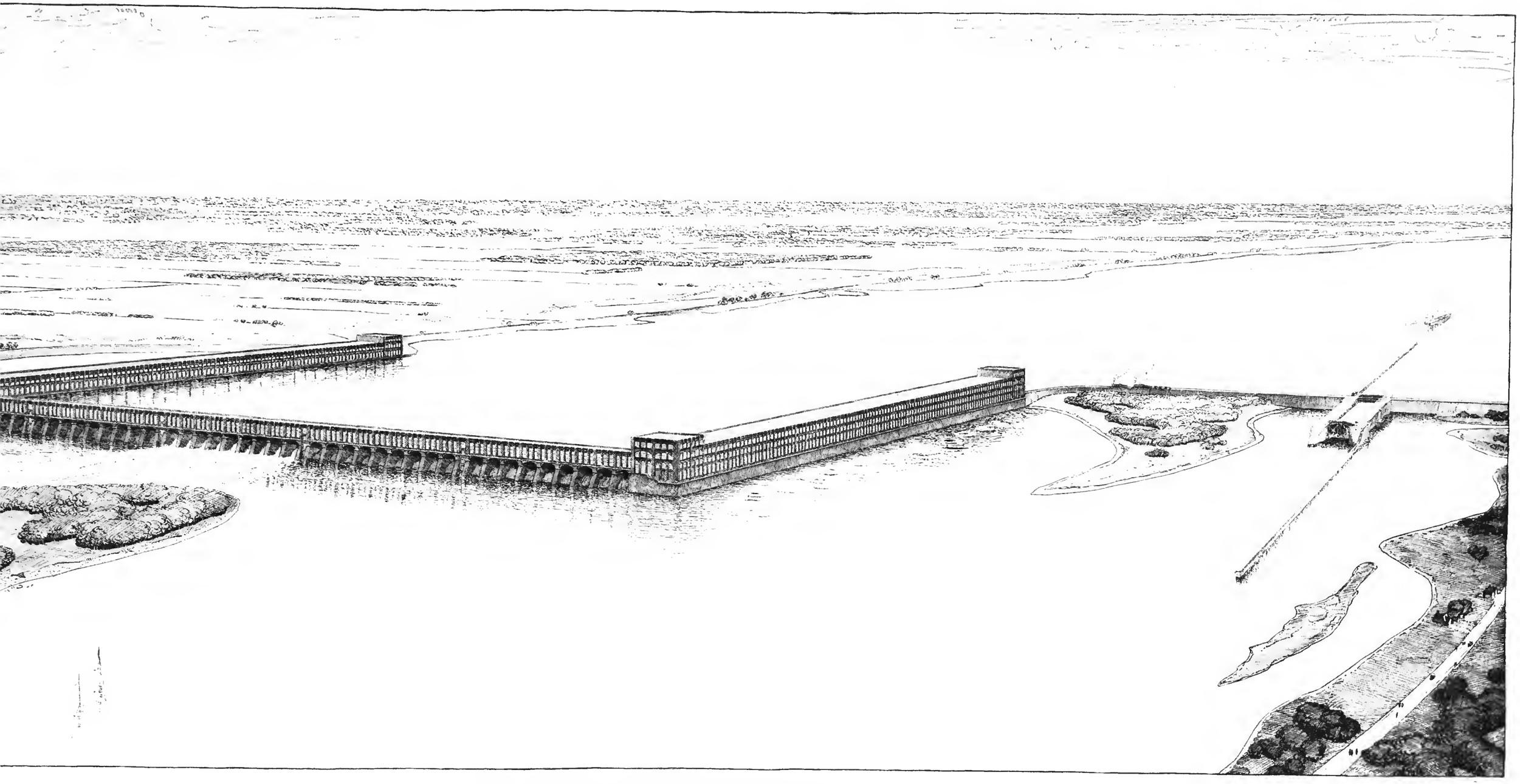


VIEW OF CROIL ISLAND PROJECT FROM CANADIAN SHORE



VIEW OF CROIL ISLAND PROJECT FROM CANADIAN SHORE

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REPORT TO

INTERNATIONAL JOINT COMMISSION

ON

NAVIGATION AND POWER

IN THE

ST. LAWRENCE RIVER

BY

HUGH L. COOPER & CO.

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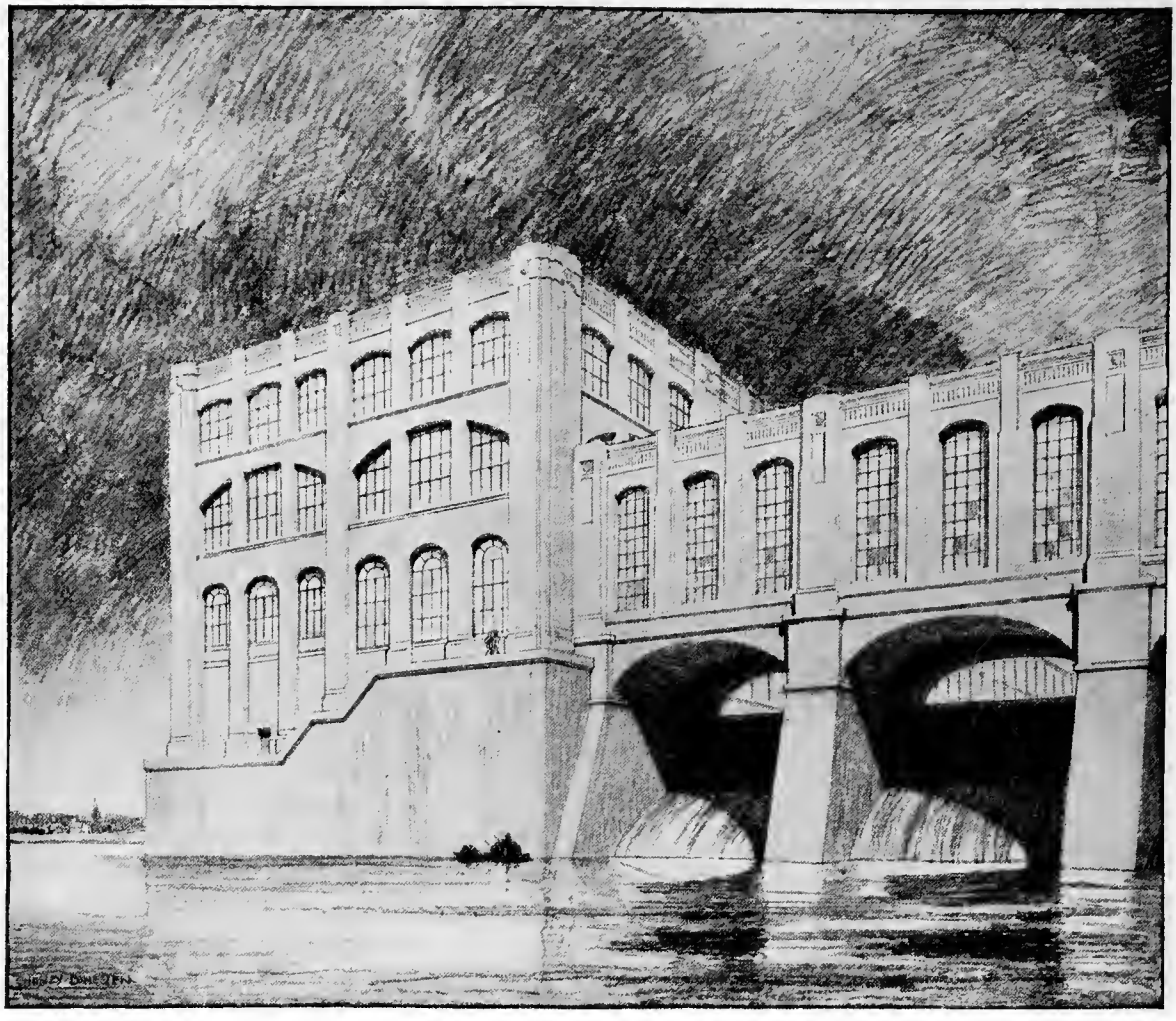


DOWNSTREAM END OF AMERICAN POWER HOUSE AND TWO MAIN DAM SPILLWAY SECTIONS

HUGH L. COOPER & CO.
101 PARK AVENUE
NEW YORK

December 28, 1920.

INTERNATIONAL JOINT COMMISSION,
WASHINGTON, D. C., AND OTTAWA, CANADA.

GENTLEMEN:

At your hearing held in New York City on October 20, 1920, I addressed you briefly regarding the navigation and power problems on the St. Lawrence River. At that time I promised to later prepare and submit to you a more comprehensive statement of my views on these important subjects, and I also requested that we be given an opportunity to reply to any competent engineering opinions that may later be submitted to you in conflict with the views herein stated.

As Consulting Engineers for the past two years we have been continuously at work investigating the power and navigation questions relating to the St. Lawrence River particularly within the boundaries of the United States, and in a general sense throughout the whole length of the St. Lawrence River. In the following pages, some results of these investigations are placed before your Commission.

We appreciate the great responsibilities now before your Commission and the necessity of having before you, in so far as possible, nothing but facts and straightforward conclusions therefrom.

We present herewith a comprehensive plan for the most efficient and economical use of the St. Lawrence River for transportation and power. We recommend the construction of a dam, which we have numbered Dam No. 1, in the St. Lawrence River above Croil Island where 1,000,000 horse power can be created, one-half for Canada and one-half for the United States. This Croil Island dam site makes feasible and controls the values of four succeeding dams below it in the St. Lawrence River, and creates in the St. Lawrence River navigation facilities we believe impossible by any other plan.

We offer for your information a description of the engineering problems at Croil Island, an outline of a financial program for the same, and a general statement with reference to the benefits we believe will result from the adoption of our recommendations.

We fully realize that your Commission will not adopt any plan of new construction in the St. Lawrence River that is not a part of the best general scheme that can be proposed both for power and navigation.

In submitting all that follows we solicit the fullest public, fair-minded, competent criticism of what we offer.

Yours respectfully,
HUGH L. COOPER & CO.

2. GENERAL STATEMENT

A horse power as used herein will mean one electrical horse power (746 watts) delivered to the low tension bus-bars of a generating station, whether the prime mover be water or steam.

For the interests we represent as Consulting Engineers, we have expended to date more than $200,000.00 solely on engineering investigations of the problems of navigation and water power from the St. Lawrence River between Lake Ontario and the mouth of the Grass River. Our conclusions are also founded upon our studies of the power and navigation questions at Niagara Falls and Buffalo beginning in 1902 and continuing, with practically no interruption, up to the present date. During this time the hydraulic portion of the 125,000 horse power plant of the Toronto Power Company at Niagara Falls, Canada, has been designed and constructed by the writer, and plans for a 250,000 horse power development in the Gorge of the Niagara River below the Falls have been practically completed. We have also made a report on the regulation of Lake Erie, the preservation of the scenic beauty of the American and Horseshoe Falls, and additional power development at the falls of the Niagara River, which has been submitted to the Chief of Engineers, United States Army.

The above investigations were supplemented and aided by the Report of 1900 of the United States Board of Engineers on Deep Waterways, by the published records of the United States Lake Survey, and by general information supplied by Canadian Government authorities.

3. PROPERTY OWNED

The interests we speak for own in fee Cat Island situated above Croil Island in the St. Lawrence River, and about 4200 lineal feet of New York shore line opposite to and above Cat Island.

They also own all the surveys, plans and reports that have been prepared by us during the years 1918, 1919 and 1920, and upon which this report is based.

They have no ownership, nor direct or indirect control of rights or of lands for their project on Canadian territory.

4. JURISDICTION OF FEDERAL WATER POWER LAW RE CROIL ISLAND SITE

On June 11, 1920, we filed application with the Federal Power Commission at Washington, D. C., for the right to build a dam in the St. Lawrence River above Croil Island, according to the terms and provisions of law set forth in Public Act

No. 280, 66th Congress, H.R. 3184, signed by the President of the United States, June 10, 1920.

During the discussions in the United States Senate prior to the passage of the Federal Water Power Law (Public Act No. 280), the question as to whether the law should apply to the Niagara and St. Lawrence Rivers was very actively debated. (See Congressional Record, January 13, 1920, 66th Congress, pages 1499 to 1513 inclusive.) The United States Senate on January 13, 1920, voted 40 to 16 to retain the jurisdiction of the St. Lawrence and Niagara Rivers under this Federal Water Power Law. This bill, including the jurisdiction of the Niagara and St. Lawrence Rivers, was passed by the House of Representatives on May 4, 1920, by the following vote: For 259, against 30.

The State of New York has filed objections with the Federal Power Commission to our application. The Federal Power Commission has, however, overruled the objection of the State of New York to the extent of ordering the advertisement of the application as provided by the Federal Water Power Law.

5. PURPOSES IN VIEW

We desire to construct a combined navigation and power project in the St. Lawrence River at the location shown on Plates 3468, page 46, and 10068, page 37. If afforded the opportunity, we will offer to provide, without governmental aid or guaranty from Canada or the United States, the control dam and two power houses and their machinery contents, the relative locations of which structures are shown on Plate 10068.

We believe that the greatest single need for the restoration of the public to normal contentment and happiness is cheap power. The construction of the works here proposed will give to the zone east of Niagara Falls, and for a radius of over 400 miles from the Croil Island site, power advantages at least equal to and probably better than those that now exist, or can be hereafter created at Niagara Falls, for reasons that will be hereinafter set forth.

The continuity of power service from the Croil Island plant will be absolute, while with but one exception every plant at Niagara Falls is subject to seasonal interruptions from ice.

The construction of the Croil Island plant, as will hereafter be shown, is the first logical step in the movement to create a 30-foot channel between the Great Lakes and the Atlantic Ocean.

It will be seen, therefore, that the zone to be supplied with cheap power will also be aided in its commercial development by the coincident creation of new navigation advantages. These navigation advantages properly coordinated with water

power and the vast railway systems now existing in this territory will give to this zone industrial advantages that cannot be otherwise created or found elsewhere on the American Continent.

We attempt herein to set forth briefly some of the great public benefits that will result should our purposes be effected. These benefits cannot become realities unless some agency, public or private, assumes great engineering, financial and construction hazards, the magnitude of which is explained in Section 10. If these risks are assumed by private capital, the estimated profits should be commensurate with the risks. We will ask no guaranties with respect to these profits; there may be a handsome profit, and there may be none.

With the foregoing in mind we are authorized to state to the Commission that the interests we represent are interested in having the proposed works built and as an evidence of good faith in this regard, we are further authorized to say that should the Commission, after a careful study of all of the proposals, recommend the adoption by Canada and the United States of the engineering plans we propose, and should the terms we offer to the respective Governments, based upon such plans, be later found unacceptable, then and in such an event all of our plans, specifications, contracts, and lands, together with properly vouchered expenditures covering the same, are available for the use of the Governments of Canada and the United States upon the payment of actual cash expenditures and 6 per cent interest, plus an amount to be fixed by you that will represent the value to the respective Governments of the work we have performed in the premises.

6. OUTLINE OF FINANCE PROGRAM

The financial program that will be hereafter proposed to the Governments of the United States and of Canada will include, amongst other provisions, the following:

(a) That all funds necessary for the construction ready for operation of the control dam 2750 feet long (See Plate 10069, page 42, for cross section) and for the two power houses each 3100 feet long, and their hydraulic and electrical contents up to and including the low tension bus-bars (See Plate 10070, page 43), will be supplied solely by the interests we represent.

(b) That all navigation facilities of whatever kind as the same may be located and required by the Governments of Canada and the United States, will be paid for, owned, operated and maintained by the respective Governments. All damages due to and caused by adopted pool levels will be paid for by the Governments of Canada and the United States. All structures connecting the upstream ends of the respective power houses with navigation facilities and the respective Canadian

and American shores will be paid for, owned and maintained by the respective Governments.

(c) That we will act as the agent of the United States and Canada in the design and construction of all the works called for in Paragraph "6 (b)" for a fixed fee equal to 6 per cent of the adopted cost estimate as the same shall be ascertained by the respective Governments when the plans for the work in Paragraph "6 (b)," as proposed by us, are approved. This 6 per cent fee will be in full payment for all of the engineering and construction services including inspection, as the same may be required, to complete the work referred to ready for commercial use. All payments are to be New York funds at par.

(d) That no duties on any materials or tools required for construction of the proposed works will be exacted by either Canada or the United States, and similarly all existing restrictions regarding the interchange of labor exclusively for this work will be waived until the works are fully completed.

(e) That there shall be at all times a free interchange of power between Canada and the United States not only during the construction period, but for all of the energy created by the proposed projects.

(f) That after the completion of all the necessary and permitting legal work, we will undertake the construction of all of the works proposed above and will agree to have not less than 400,000 horse power ready for delivery from the American power house, subject to delays beyond our control, in approximately 60 months after the date of the execution of the final legal documents. We will install the balance of approximately 600,000 horse power at such unit rate of installation as is necessary to supply growing market demands. The final legal documents might well contain provisions for the use in the United States of power from the Canadian power station as and when Canadian market requirements permit.

(g) That from the first installation of 400,000 horse power, we will agree to supply for use in Canada as and when called for (subject always to an advance notice of 20 months) the whole or any part of 50,000 horse power at a fixed price on the low tension American power house bus-bars.

(h) That as and after the Canadian market requirements exceed 50,000 horse power, and if such excess requirements occur when they cannot be supplied from the American power house, then and in such an event we will install and complete ready for commercial use on the Canadian power house foundations, the necessary operating units according to specific plans and specifications previously agreed to, and at such rate of readiness for commercial use as Canada upon three years' notice may demand. The work called for in this paragraph will be paid for by Canada at a guaranteed rate per complete unit installed plus a prorated cost of

the Canadian half of the control dam. These costs will be named in proper contracts therefor, and when such units and the Canadian half of the control dam are paid for by Canada, they will become the property of the Canadian Government for such use as Canada may determine.

7. SUMMARY OF THE PROPOSAL

From the foregoing paragraphs, "6 (a)" to "6 (h)," both inclusive, it should be apparent that we seek an opportunity to finance and construct approximately 1,000,000 horse power of capacity for use in Canada and the United States at costs to the consumers that will be foreknown and guaranteed and on terms that do not call for governmental aid except for the navigation facilities, in which practically all of the people in both countries are interested.

No attempt will be made at this time to place before you our detailed estimate of the cost of the proposed works. Based upon our estimate, the cost of power to consumers in Canada and the United States, exclusive of Federal or State taxes, will be $17.00 per horse power. The Commission, upon inquiry, will find that this price is less than can be secured for similar service from future new installations at Niagara Falls, whether publicly or privately owned, either in Canada or in the United States.

The total cost of the facilities in "6 (b)" to the respective Governments, is estimated not to exceed $30,000,000.00 for a 30-foot channel.

8. TAX ON WATER POWERS

The question of whether States or Nations should place an arbitrary annual tax per horse power on all water power developments primarily because they are founded upon national resources, is one that has from time to time been prominently in the public mind.

We believe that such a plan is poor economics and not in the public interest. All such taxes are added arbitrarily to the power selling price and are in no sense a burden upon the power company, but upon the eventual consumer of the products that are manufactured with the power.

A tax of sufficient amount to take care of administration expenses would be appropriate. A tax of an appreciable amount for revenue purposes, however, will either prevent the developments being made or deprive the population within reach of these power plants of the full benefits of the natural resources within their State to the extent of the tax, whatever the amount may be. If the principle were adopted that water powers should be specially taxed as above indicated, then a similar tax should be applied to all industries founded on natural resources and such a similar tax would be impracticable.

We believe the vast amount of new property that can be encouraged to come into a zone where power is especially cheap and free from tax, is of far greater value to the public as a whole than are the values represented by any direct horse power tax.

In countries so richly endowed with natural resources as is the case in the United States and Canada, it will undoubtedly be found best for the population as a whole to have the freest and most complete development under strict regulation as to price and service of these resources as is possible, rather than development restricted in even a small degree by the imposition of national or state taxes.

On this question of taxation of water power, it may be well to consider the following: One of the tangible results of the war is that more than half of the world is down and out in an industrial sense and cannot possibly even begin to recover until credits are extended by the United States, Canada and England permitting the purchase of raw materials. Every thoughtful person knows that the days of orgy-spending are over for a long time to come. Big and little, rich and poor must practice careful economies in all their expenditures until credits all over the world are restored to a normal basis. This campaign of economy cannot be made effective in private life if it is not practiced in public life and in reference to public affairs. It behooves every government to set the example of frugality by the wise use of monies and natural resources. The wisest use of the great natural resource here discussed will require, in our judgment, the eventual adoption of all of the recommendations herein made.

It seems certain that no permanent peace and prosperity can come to the United States, Canada or England until the afflicted countries are at work and producing exports. If this is sound doctrine, these countries, in order to become reestablished will, of necessity, have to send their productions abroad and sell them at a profit, in order to pay the raw material loans that enable them to recover. The cheap labor that will produce these exports will be in competition with wage scales on the North Atlantic Continent, and unless our American labor can be supplied with counterbalancing economies, we will be unable to meet this new foreign competition.

One remedy for such a contingency would be to reduce our wage scales to the scales of foreign labor, a remedy that no republican form of government would dare to consider for a minute. The alternative, therefore, is that our manufacturers, in order to maintain wage scales and compete with foreign industry, must be afforded every economical agency our combined ingenuity can contrive, and certainly to add a tax to such ingenious work is not in the interest of the public at large.

9. NAVIGATION AND POWER ON THE NIAGARA AND ST. LAWRENCE RIVERS

In the territory in the United States and Canada above the fortieth parallel there exists today a population of more than ten millions of industrial and agricultural people whose best employment will have a widely beneficial influence on the balance of the population of the North American Continent. This relationship is founded on the fact that the Great Lakes and the Niagara and St. Lawrence Rivers taken together are undoubtedly the largest undeveloped resources of their kind in the world. The percentage of their present development to the rational ultimate development is so small as to be negligible. There is the following urgency at this time for the intelligent development of these natural resources to their fullest capacity and best efficiency.

The World War removed 20,000,000 men from the man power supply of the world, and these losses are in a large part in the countries that America has hitherto been calling upon for its common labor supply. To an unusual degree in Canada and the United States, native Canadians and Americans have long ceased to perform purely manual labor in an acceptable manner, preferring as is undoubtedly their right, skilled and supervisory employment. It is perfectly obvious that the world can not recover from the results incident to the loss of 20,000,000 men except through and by the substitution of new labor saving engineering works. Upon the successful solution of this need depends the future happiness of mankind. If success is attained, we can continue to advance, otherwise we must, as a people, recede to a less desirable scale of living.

You have heard extended arguments as to the great need of increased transportation facilities not only upon the Great Lakes, but upon our present railroad facilities, and the desirability and priority in importance of making the best possible use of the St. Lawrence River as a navigation medium is unquestioned.

The combined average United States and Canadian up-and-down river tonnage movement on the St. Lawrence for the years 1912, 1913 and 1914 was 4,942,000 tons. To appreciably increase this tonnage the cost of freight transportation must be reduced to a business getting rate. Cheap water borne freight rates depend upon the speed at which the vessels can navigate and upon the draft of the vessels. The best testimony we have been able to assemble is to the effect that ocean vessels will never use the St. Lawrence River unless the maximum of open pool navigation is provided between Montreal and Lake Ontario.

In this stretch at present a boat must traverse 46 miles of canal and pass through 21 locks and for long reaches of the river must encounter velocities that are difficult of navigation. The necessary Welland Canal section is a great handicap to ocean

going freight and to overcome this handicap, the St. Lawrence River approach must be made as free from all further objections as is possible.

Ocean vessels in the Great Lakes trade must find other business during the closed season and when we consider that the most economical capacity (10,000 tons) for an ocean vessel drawing 30 feet costs about 90 per cent more for operation per ton mile than the corresponding lake carrier, we get a fair view of the need for the adoption of the most inviting facilities in any reconstruction program applicable to the St. Lawrence River.

On Plate 3468, page 46, we have shown a general profile which we recommend being adopted, believing as we do that the arrangement proposed will meet the unusual demands of navigation improvement as above outlined. In the 120-mile stretch between Lake Ontario and Montreal, we propose the construction of 5 dams, 6 locks, 116½ miles of open pool navigation and 3½ miles of canal.

We estimate to obtain the ideal navigation conditions shown on Plate 3468 without any assistance from water power would cost approximately $550,000,000.00. Assuming that the Governments of the United States and Canada can in the future borrow money at an average interest rate of 4½ per cent and that 1½ per cent will be required for operation, maintenance and depreciation, we have a total charge against an ideal navigation system on the St. Lawrence of 6 per cent on $550,000,000.00 cost, or $33,000,000.00 per annum. This would be equivalent to $6.66 per ton tax on public funds for the existing traffic on the St. Lawrence section alone, to say nothing of the actual transportation charges.

If we assume that through the construction of many great industries in the future, tributary to the Great Lakes system, that eventually the St. Lawrence tonnage could be increased to 25,000,000 tons per annum, we have a fixed rate of $1.32 per ton for the navigation facilities on the St. Lawrence section alone, exclusive of the actual transportation charges, and this $1.32 is a charge the traffic can never bear.

If the plans we are proposing are carried out and water power is developed along with navigation, as it should be, in the St. Lawrence section, the total charge against navigation will be reduced from $550,000,000.00 to $150,000,000.00 of capital investment, which at 6 per cent will amount to $9,000,000.00 a year by way of fixed charges, thus yielding a charge of 36 cents a ton against the transportation facilities when the annual tonnage is 25,000,000. Such a low charge would be a great stimulant, but no such stimulant can ever be secured without the aid of water power.

While on this question of the navigability of the St. Lawrence we desire to point out that the existing great east bound tonnage on the Great Lakes of approximately

50,000,000 tons per annum consists almost entirely of ore and this traffic practically ends at Cleveland. Very little of it would ever pass though the St. Lawrence River even though a 30-foot channel were available. This ore tonnage at best is very transient and in a few years will be a negligible quantity.

We are of the opinion that justification for the installation of a 30-foot channel facility through the Great Lakes to the sea must by found solely by the development of many new industries of a varied character near this great waterway and in a large way these industries will be found eventually based upon water power. When this eventuality will become a reality depends almost entirely upon how soon actual facts are properly recognized and acted upon by public authorities in Canada and the United States.

Before entering upon a discussion of the general benefits accruing to the public at large from the installation of cheap water power, we desire to state our belief that the most rapid installation of new industries founded upon water power will be fostered by the best improvement of navigation facilities throughout the Great Lakes and the St. Lawrence River.

We desire now to submit a partial list of the advantages obtainable only by the sensible development of water power and as power is a basic industrial necessity and not a luxury, the list is of peculiar importance at this time.

(a) Water power is now the most satisfactory form of power man has devised and it is practically the only major need that has remained substantially at pre-war prices all through the war.

(b) Every 35 hydro-electric horse power installed saves the labor of one laboring man annually.

(c) Every hydro-electric horse power saves on the average (as coal is now being consumed in existing steam stations) more than 10 tons of coal per annum.

(d) To produce any given quantity of steam electric power, there is required more than 70 times as much labor as is required to produce the same quantity and class of hydro-electric power.

(e) The average cost of steam power in all the installations, big and little, in the United States and Canada was about $70.00 per annum before the war and this cost is probably $110.00 per horse power per annum today. The average cost in the United States and Canada for hydro-electric power on generating station bus-bars is less than $20.00 per horse power.

(f) It is conservatively estimated that on the average every hydro-electric station that is installed on the American Continent saves the eventual consumer $35.00 per annum per horse power.

(g) Water power cheapens freight rates on general commodities because through saving of coal, railroad property is released for more productive uses.

As this claim (g) has hitherto been given very little, if any, attention, we beg to offer the following in support of the same. All the railroads in America are sadly overtaxed at this time principally because for the last ten years their credit has prevented them from borrowing the money needed for extensions and betterments. This adverse credit situation should obtain in a degree lessening each year for some time to come. Any program that will reduce existing demands on railways by an appreciable percentage will, therefore, be a distinct relief to railroad financial needs, especially if the freight that is withdrawn from the railroads is a commodity upon which the return is low.

Thirty per cent of all the railway property in the United States is occupied in the transportation of coal.

It will be interesting to analyze the effect on the railways in the zone under consideration of the withdrawing from their service of 66,250,000 tons of coal per annum referred to in paragraph (j), of this Section.

As the results may be surprising, we submit the following data we have used in arriving at these conclusions:

(a) We have assumed that the average distance from the mine mouth to the point of consumption would be 150 miles.

(b) The rate of travel for coal cars, empty and loaded, 30 miles per day.

(c) The weight of coal carried in each car, 50 tons.

(d) Forty cars per train, loaded; 120 cars per train, empty.

(e) Cost of coal cars, $3,000.00 each.

(f) Cost of freight locomotives, $55,000.00 each.

(g) The valuation of all railways in the United States, as determined by the Interstate Commerce Commission, for the year 1919 was $20,040,000,000.00.

(h) From the Commission we learn that about 21 per cent of the total valuation above is represented by freight cars and freight locomotives.

(i) Without any allowances for strikes, snow blockades or other unusual interruptions to move 66,250,000 tons of coal annually would require 36,000 freight cars and 600 locomotives, the value of which alone would be $141,000,000.00.

(j) If freight cars and freight locomotives are 21 per cent of the total value of railway property, then $671,400,000.00 of existing railroad property would be released for other general public service by the installation of 6,625,000 horse power, and the attending annual saving of 10 tons of coal per horse power, or 66,250,000 tons.

All the foregoing bases of computation are ultra-conservative. Surely to secure

such an added railway facility is of first importance and is worthy of support from the railways and especially from the consumers whose rates are dictated solely by the earning capacity of our railroad properties.

In the zone here discussed there is now developed and in commission approximately 850,000 horse power; 680,000 horse power from the Niagara River and 170,000 horse power from the St. Lawrence River. Comprehensive official examinations conclusively show that at Niagara scenic beauty can be appreciably increased and permanently preserved and allow the development of at least 2,305,000 horse power. The necessary remedial works do not invade any speculative field and can be completed in harmony with further diversions above the Falls. From the foregoing it is evident that at Niagara Falls, 1,625,000 new hydro-electric horse power are available for present and future needs.

On the St. Lawrence between Lake Ontario and Montreal, our studies show that there are slightly over 5,000,000 (1,000,000 in the United States and 4,000,000 in Canada) new hydro-electric horse power available for present needs and future use, thus showing within the territory under consideration, the existence of 6,625,000 undeveloped hydro-electric horse power. Official United States statistics indicate that the present installed water power capacity in the United States is about 10,000,000 horse power. We are of the opinion that this estimate is considerably too high. Assuming the 10,000,000 estimate to be correct, for comparison purposes, we find that the undeveloped power herein discussed is more than 66 per cent of the total developed water power in the United States. Owing to the constant flow available on the Niagara and St. Lawrence Rivers, the actual kilowatt hours of energy possible from the 6,625,000 horse power will be at least 25 per cent greater than the number of kilowatt hours possible from the 10,000,000 hydraulic horse power now installed in the United States. The statistics of the United States Census for the year 1920 will show that the consumption of power from central power stations, per one thousand of population, is 160 horse power. Applying this ratio to this latent undeveloped resource we find that the St. Lawrence and Niagara power units will be capable of supplying the power needs of over 41,000,000 people. The saving in man power will be around 190,000, affecting a population of 950,000, all of which will be available for other more profitable uses amongst which might be enumerated agricultural and manufacturing production needs.

As before stated, the saving to the consumer as between generating costs from water power and from steam power in the territory under consideration, will be at least $35.00 per annum per horse power. This saving applied to the undeveloped horse power under discussion means an annual saving of $231,875,000.00. Before the war the average rate of earnings for all investments all over the world

was 12 per cent. A saving of $231,875,000.00 would be in effect, a profit to the consumers. On a 12 per cent earning basis, an investment of $1,932,000,000.00 would be necessary to secure the profit for the public that can be obtained by the development of this 6,625,000 horse power.

The creation of a vast water power zone will attract great chemical and fertilizer plants that will give to all our people the necessities that cannot otherwise be obtained. The distribution and enjoyment of these necessities will, through cheap navigation and railroad rates, be felt all over Canada and the United States.

In addition to the benefits above mentioned, any one of which is startling in its dimensions, it should be here stated that while the installation of 6,625,000 horse power will cost, in round numbers, $1,300,000,000.00. the final installation of this horse power will carry along with it in the way of new industries, at least $2,000,000,000.00 more of investment values for taxable purposes, if the past history at Niagara Falls and elsewhere is to be used as a guide. In other words, between the eastern end of Lake Erie and Montreal there are undeveloped water power resources upon which there can be sensibly founded more than $3,300,000,000.00 of much needed new industry, and this vast prospect can be undertaken in such steps and in such sequence of development as the best needs of the people in Canada and the United States require.

If competitive engineering and industrial brains can be given a fair chance, the consumers can some day enjoy the above profits and general benefits from water power without contributing directly or indirectly one dollar, and at the same time have the power rates and service fixed and controlled by their own appointees—the public service commissions.

You may well inquire as to possible market demands for such a vast amount of power. Our reply is that there is an existing market in the United States justifying the immediate development of the Croil Island site, and that if the future can be judged by the past history of the hydro-electric industry, market demands for cheap, reliable hydro-electric power will always outrun the supply.

As to why this potentiality has not received a closer attention in the past, the answer to such a question would be found principally in the history of the development of hydro-electricity. In 1888, hydro-electric power units of 1,000 horse power, and the use of transmission voltages of 10,000 were achievements that looked large at that time. In 1888, forty per cent of the theoretical power represented by the head of water used was all that was obtainable. Today transmission voltages of 220,000 volts are in successful commission and turbines and generator units of 50,000 horse power each are entirely feasible and are now being installed. Instead of the 60 per cent losses in generation that obtained in 1888, we have

now only 10 per cent losses. The efficiencies for generators and turbines have remained practically stationary for the last five years. It is believed that the limit of efficiencies has been reached, and therefore, that hydro-electric plants built at this time will be free from future obsolescence charges as regards efficiency and capacity.

Over 72 per cent of the power here discussed is in Canada. While the boundary line between the United States and Canada is a political fixture theoretically separating two great peoples, it is the belief of the best thinkers that as time goes on the interests of these two countries will be found conflicting less and less and that the greatest prosperity in either country will be found when both are highly developed and prosperous. The development of this 72 per cent of cheap power in Canada will be of marked benefit to the United States in many ways besides in the saving of United States coal noted below. It is especially important to the United States that exports of coal to Canada be reduced to the lowest minimum as rapidly as possible. A lessening in the shipments of coal to Canada will reduce the cost of coal to steam users and for heating purposes in the United States, because any reduction in demand is always followed by a reduction in cost. It is a striking fact that hydro-electric energy reduces the cost of its only competitor—steam.

Some hesitation has been experienced as to the wisdom of submitting to you the foregoing because of the fear that the magnitudes dealt in may cause the Commission to doubt the various items as set forth. The statements, however, are all facts.

Having set forth some of the benefits that will result from the most wise improvement of the St. Lawrence River with reference to the value of this river as a part of the Great Lakes and St. Lawrence navigation systems, and as to the value of the St. Lawrence as a water power medium, we desire to speak of the methods that should be employed to bring these proposals into commercial existence.

We are of the opinion that neither navigation nor power should be developed in either country until a justifying tonnage and power market are shown upon careful investigation to be reasonably available. The outstanding necessity from now on of great care and economy with reference to all of our industrial affairs will undoubtedly cause the public, now and in the future, to insist that all new ventures must be thoroughly sound, and fully take care of construction costs, interest, upkeep, operation, and sinking funds.

We believe that a careful estimate of the project as set forth in the Engineering Section of this report will show that the amount of work herein outlined is of greater magnitude with respect to cubiture, engineering difficulties and total costs than has ever been proposed in the past. In the St. Lawrence section alone the esti-

mated final costs are $1,450,000,000.00 (for water power $1,300,000,000.00, and for navigation $150,000,000.00).

We believe the first important step in this proposal will be the construction of Dam No. 1 as a navigation and water power unit, for reasons set forth in Sections 5 and 11.

The first question to be settled will be as to whether the undertaking shall be financed, constructed and brought into operation by private capital or by public capital administered by governmental agencies.

10. PUBLIC OR PRIVATE OWNERSHIP AND UNIT CONTROL OF CONSTRUCTION WORK

The engineering difficulties incident to the building of a 1,000,000 horse power plant in the St. Lawrence River are divided into two classes: First, those of design, and second, those of construction. The engineering designs that are necessary are of very easy determination because they follow well established precedents, and do not in any sense invade the experimental field in major elements.

Recent achievements in water wheel and generator designs, and in navigation lock design are so closely similar to the needs for the Croil Island development that no difficulty is anticipated respecting the adoption of final plans. Substantial difficulties, however, relate to those of construction.

No great dam has hitherto been built anywhere except in locations offering seasons of low flow for the installation of the necessary temporary works. Forty thousand cubic feet of water per second has hitherto been considered an excessive amount of water to handle at the time cofferdams were being placed. On the St. Lawrence, cofferdams will have to be placed when four and one-half times as much water is being discharged as has been hitherto successfully controlled. The depth to foundations on the St. Lawrence is more than 65 feet for an average of 15,000 lineal feet of masonry work. The length of time required for the work will be at least five years, thus necessitating that temporary construction, including the cofferdams, must, as a matter of fact, have the stability of permanent structures in order to sustain the labor of five unknown seasons in a great river.

This depth of 65 feet and this 15,000 feet of width call for the unwatering of an under-water area six times as large as any work of this class hitherto accomplished. Navigation can not be interrupted during the five-year period that the works are being constructed. In order to properly handle the elements and difficulties that will be inherent in the successful engineering construction of works costing around $200,000,000.00, it should be perfectly obvious that such an undertaking can never be accomplished except through a unity of direction that will have

to be lodged in one organization controlled by men whose previous achievements will justify the work being undertaken at all.

We are of the opinion that it will not be possible to successfully carry out works of the kind above described through any government agency at any price, and that if the public is to enjoy the benefits they are entitled to, they will secure this enjoyment by the adoption of competitive plans from private capitalists and engineers for the various steps that should be logically adopted for this work.

We believe the history of the Panama Canal substantiates the foregoing view. The Panama Canal project was exhaustively studied and reported upon for more than twenty-five years prior to 1900. In 1899-1901 a United States Board of Engineers submitted to Congress plans for a canal estimated to cost $144,233,-358.00, including sanitation and police. In 1902, the Spooner Act was passed authorizing the construction of the canal and limiting the expenditure thereon to $145,000,000.00, including sanitation and police, and exclusive of payments to Panama and the French company. In 1906 Congress adopted the report of a minority of the Board of Consulting Engineers, fixing specifically the type of canal that was to be built, and their estimate of cost of $139,705,200.00, excluding the Panama and French purchase prices, cost of sanitation, civil government and interest. The Annual Report of the Isthmian Canal Commission for the year ending June 30, 1909, shows that the expenditures up to that date, solely for construction, engineering and plant, were $95,120,391.00. Rapid exhaustion of appropriated funds and knowledge gained through the expenditure of the major portion of the above $95,120,391.00, caused the issuance of another revised plan and estimate, and its submission to Congress in February, 1909, showing that the cost of the Panama Canal would be $297,766,000.00, excluding same items. The 1909 Report called for a canal fifty per cent wider through the Culebra cut, called for increased lock dimensions and for certain other auxiliaries not included in the $139,705,-200.00 estimate.

The official report of the Governor of the Panama Canal for the year ending June 30, 1918, shows the canal cost to that date, $289,930,309.00, which should be compared with the estimate of 1909, of $297,766,000.00, thus showing that the estimate of 1909, based upon previous experience, was correct and as such is a splendid showing greatly to the credit of all concerned.

Up to June 30, 1918, the canal cost the United States Government $150,225,-109.00 more than Congress expected it would cost when the building of the canal was authorized in 1906, or a 107 per cent overrun. The changes in the width of the canal through the Culebra cut, the increased dimensions of locks and the other auxiliaries represent but a minor portion of this $150,225,109.00 overrun. This

statement is not made in criticism of any engineer or engineers responsible for this great project, but to illustrate the possibility in large engineering projects of unforeseen changes and additions greatly increasing the cost of a project as compared with the original plans and estimate.

Quite apart from the above comparisons, *re* estimated cost of the project in 1906 and the result in 1918, it is interesting to note that if the Panama Canal had been charged four per cent compound interest (as all government projects should be assessed if true costs are to be declared) for the money it has cost up to date and including the recent vote of $25,000,000.00 for Colombia, and including fortifications and all costs incident to the work, exclusive of maintenance and operation, the total levy against the United States Treasury becomes in excess of $625,000,000.00.

If the plans we propose are adopted, the Governments will be fully safeguarded against such increased expenditures by guaranties that will be found satisfactory.

Similar exalted examples of governmental undertakings in the United States, Canada and European countries can be cited in support of the belief that it is never in the public interest to do anything with a government agency that can possibly be accomplished by an intelligently regulated private agency. Human nature will always be found revealing about the same general characteristics. In government control, energy and initiative are wanting, and in the great majority of cases more zeal is devoted to holding the particular job, big or little, than is directed to the best execution of the multitude of things that spell success. If there were any doubts in the past on this great question, the war has settled them in favor of relief from governmental management wherever it is possible.

In the foregoing criticism of governmental management, we are fully conscious of the fact that there are many able men in the government service, but these able men are a helpless minority and we fully believe that most of them agree with the views we here set forth.

The time of the Commission will not be taken up in the consideration of the many difficulties that would be involved in trying to manage the St. Lawrence River project through the instrumentalities of more than one organization. The impossibilities are so numerous and obvious as not to require enumeration at this time.

11. LAKE ONTARIO STORAGE AND ST. LAWRENCE ICE AND POWER PROBLEMS

The best development of the St. Lawrence River for navigation and power requires that the first installation shall be at a point in the St. Lawrence River that can regulate the level of Lake Ontario, that can thus balance the flow of the

St. Lawrence River and that can forever settle the existing and forbidding ice troubles in the St. Lawrence River as far as power is concerned.

Our examinations demonstrate that the above needs can only be secured by a development at Croil Island according to the plans we herein illustrate and propose, unless great sacrifices of power are to be sustained. Four major considerations upon which this decision is based are as follows:

(a) The regulation of the levels of Lake Ontario is important, not only from the standpoint of navigation, but from the standpoint of balancing the flow of the St. Lawrence River itself. In the plans we have prepared, we propose to maintain the level of Lake Ontario between 247.50 for the high level (the existing high level is 248.96) and 245.00 for the low level, thus providing two and one-half feet of storage. In the past in Lake Ontario, low navigation levels have been encountered of 244.16, and our low level in the navigation season will be 245.50, a gain of a foot and three-tenths in the navigable capacity of Lake Ontario itself.

(b) The regulation of Lake Ontario, the mean area of which is 7243 square miles, and the 2.5 feet of its depth for storage purposes, we propose to use as follows: Six inches of depth will be held constantly in reserve for winter and early spring use in handling ice as exigencies require, and twenty-four inches will be used for balancing the flow of the St. Lawrence. This six inches of depth will provide 100,000 c.f.s. continuously for 265 hours. This 265-hour capacity would be used in periods varying from 24 to 120 hours and would be available for all the dams below Dam No. 1 as and when they are constructed. This plan of controlling the ice movements by manipulating the gates and changing pool slopes is of first importance and is believed to be the only solution possible for this very troublesome and threatening question.

The ice question in the St. Lawrence is a very grave matter and the method of its control must be absolutely settled before either public or private capital will be justified in building extensive water power plants on the St. Lawrence. Modern industry cannot thrive on the constant interruptions to service that would certainly ensue with the ice question unsolved. Existing plants in the St. Lawrence on both sides of the river offer abundant testimony supporting the above view and prove that the only form of power industry that can subsist on the St. Lawrence River under present ice conditions are industries given over entirely to chemical production where interruptions to service are relatively unimportant. The general public, however, needs water power for many things besides chemistry, and these needs require constant service, and this constant service demands a regulation and control of the ice as above noted.

The pool levels adopted in our plans produce velocities that will permit pool

surfaces to freeze over and so prevent the formation of frazil which long experience has shown cannot be otherwise obviated. Temporary manifestations of frazil before pools freeze, due to wind action, can be carried through the water wheels.

The above allotments of water for ice flushing purposes are considered conservative, and the particular methods that will be employed in using the same are later described.

(c) The 24 inches of storage will balance the flow of the St. Lawrence and yield an available flow for navigation and power purposes of 224,000 c.f.s. after Lake Erie is balanced, or 217,000 c.f.s. with Lake Erie unbalanced. The availability of 217,000 c.f.s. for power purposes can not be effected unless the ice is handled by stored supplies of water. In winter seasons without stored water for ice flushing purposes, the low unbalanced flow of 160,000 c.f.s. might be reduced to 60,000 c.f.s. for power purposes as compared to 217,000 c.f.s. as here provided. The benefits to navigation on the St. Lawrence due to balancing the flow will not be appreciable in the 120 miles between Lake Ontario and Dam No. 5, but will be appreciable at Montreal. The augmentation of the ordinary low flow of the St. Lawrence River, through storage from Lake Ontario, by 40,000 c.f.s. will increase the present low navigable depth of the river fifteen inches at Montreal.

(d) The expense of the Croil Island installation will be considerably more per horse power than will be the case of any of the four dams below it.

It will be observed on Plate No. 3468, page 46, that we are recommending a new level below Dam No. 1 for the discharge of 220,000 c.f.s. The present level at this point when 220,000 c.f.s. are being discharged is Elevation 204.65. We are proposing that this level shall be reduced to Elevation 201.00 for the same discharge, and that this reduction of level be accomplished by deepening the existing channel at the head of the Long Sault, and at Farran's Point as indicated on Plate No. 3468. If the pool levels are adjusted as above recommended, the operating head at Dam No. 2 will be slightly better than would be the case if the channels at the head of the Long Sault and at Farran's Point were left as they are now.

The large amount of additional power available from Dam No. 2, because of the balancing of the St. Lawrence flow by Dam No. 1, will much more than counterbalance the loss of energy that will result at the Aluminum Company of America's existing power plant at Massena, N. Y.

In so far as the horse power cost for the whole 5,000,000 new horse power is not increased thereby, it is of importance to the consumers that the actual investment per horse power at each of the five locations be brought as near to the average cost of the five installations as possible. In this reasoning it is assumed that prac-

tically all of this energy will be regulated as to price and service by public authority in Canada and the United States. This being the case a wide difference in the capital costs of power would present difficulties in the way of regulation that should be avoided if possible.

It would seem, therefore, that with respect to Dams 2, 3, 4, and 5, that eventually an equitable adjustment of the capital costs at these four sites will call for the payment to the Croil Island site of a differential to be measured and determined by governmental authority as and when the benefits bestowed are in commission.

12. CAPACITY—BALANCED FLOW—HEAD

The capacity of each power house will be approximately 500,000 horse power. It is proposed to use the flow of the St. Lawrence River on an 80 per cent daily load factor.

The balanced flow at Croil Island from Lake Ontario alone will be 217,000 c.f.s. The balanced flow of the St. Lawrence River at Croil Island, after control works for Lake Erie are in commission, can be commercially assumed at 224,000 c.f.s. The use of the daily load factor of 80 per cent will cause momentary and intermittent withdrawals up to 280,000 c.f.s. A discharge of 280,000 c.f.s. will not cause a velocity in any of the stretches of the river affected by this withdrawal, exceeding 3.6 miles per hour for a reach less than one mile long.

The operating head when 224,000 c.f.s. are flowing through the power houses and control system will be 40 feet.

13. ENGINEERING

We desire now to proceed to the discussion of the general plans we have prepared for the Croil Island, or first development. The plans we have attached hereto are only a small part of the total we have prepared. Before the adoption of the general design here submitted, and after the foundations were located, three trial designs were worked out and completed with the result that the layout shown on our Plate 10068, page 37, in our judgment, offers the best solution of the various problems that are here to be met.

It should be understood that the indicated locations for the Croil Island works are subject to such minor changes as further drilling requires.

Plate 3461

Plate 3461, page 35, is a general map showing Lake Erie, Lake Ontario and the St. Lawrence River as far as Quebec and the geographical location of five dams proposed in this report.

Plate 3319

Plate 3319, page 36, shows the location of the Croil Island dam site with reference to Ogdensburg, N. Y., the easterly end of Lake Ontario.

Plate 10068

Plate 10068, page 37, shows the general location of the proposed Croil Island works.

The lock located between Steen Island and the main shore affords a perfect harbor.

In submitting Plate 10068 for your consideration, we appreciate that it is a radical departure from plans hitherto proposed in the St. Lawrence and elsewhere for the regulation and control of pool levels where water for power purposes is an important integral part of the whole design. A reference to Plate 3319, page 36, will show that for a distance of three miles upstream from the main control dam, the thread of the stream is in point of direction at right angles to the control dam. This fact is important because it provides a straightaway course for all ice that will approach the works. The vast amount of ice that will have to pass through the control dam requires that the success of handling it shall not depend either upon deflecting it from its natural course, or upon the action of man operated machinery where the same is exposed to the rigors of low temperatures common at this site.

It will be observed that the water for power purposes is taken from the forebay at right angles to the general direction of the flow of the river. Inasmuch as the water thus diverted at right angles is kept free from ice by the longitudinal masonry boom in front of the wheels, no difficulty will be encountered in such clear water diversion.

At other localities on the St. Lawrence and elsewhere in latitudes of low temperature where power houses have been constructed at right angles to the general direction of flow of the stream, and where independent deflecting works have been depended upon to keep ice away from turbine chambers, there have always been very serious interruptions to service that should not be allowed in a plant as important as the one here under consideration.

Whereas the cost of the works might be considerably reduced by a different arrangement of control system to power house than the one here proposed, the Commission would not be warranted in allowing such economy because of the certain interruptions to service that would ensue. We believe that the same general arrangement with respect to control dam and power houses shown for Dam No. 1 should be adopted for Dams 2, 3, 4, and 5.

We are quite sure that any power development on the St. Lawrence River, above

Croil Island, must be located at or very near the site shown on Plate 10068, page 37. Any location above this site would result in an operating head less than 40 feet and would therefore require increased power house lengths resulting in prohibitive costs.

Work of this magnitude requires large areas of water cross section because of the increased velocities due to cofferdams, and such necessary areas can not be found above the recommended site.

Plate 10006

Particular attention is directed to Plate 10006, page 38, being a two-foot contour map of the terrain adjacent to the proposed site and also the same contours for the bed of the river. These contours are from specific instrumental measurements throughout, and over 13,600 readings were made in the field before the preparation of this map was undertaken and concluded. The unusually large quantities of masonry, excavation and water to be handled throughout the undertaking, made the ordinary methods of estimate impossible and required the careful execution of this contour map in order that the proper designs could be worked out and estimated.

Plate 10016

Plate 10016, page 39, shows typical drill holes accomplished by the use of diamond drills for the purpose of determining the character of the overburden above the rock and the character and depth of the rock for foundation purposes. Fifty-six holes of this character were drilled between contours 248.00 on each shore following around the axes of the various structures including the lock.

From these holes about one-half mile of rock core was taken and the firmness of the rock, together with its uniformity, was responsible for the recovery of more than 70 per cent of the rock cores in these holes. The character of the rock is a hard blue dolomitic limestone weighing 167 pounds per cubic foot. During the course of this drilling, each of the five drills was attended by an independent inspector. Throughout all of the rock drilling no seams were encountered and the foundations are entirely adequate for the purposes here proposed.

In two cases the drills were driven 100 feet into rock.

Plate 10009

Plate 10009, page 40, is a typical drawing showing the bed rock profile and the extent and character of the overburden between the indicated stations.

Plate 10076

Plate 10076, page 41, shows a cross section of the river at the power house and

cofferdam lines and on the forebay and tailrace lines. These cross sections illustrate the large amount of overburden that will have to be encountered through these areas.

Plate 10069

Plate 10069, page 42, illustrates a cross section of the main dam, and your attention is invited to the fact that the average level of satisfactory foundation rock is approximately Elevation 135.00, something over 69 feet below standard tail-water level. It will be observed that we propose to control the level of the pool created by the construction of the dam by the use of steel control gates fifty feet long, held in position by piers ten feet thick. The capacity of these gates will be sufficient to handle 450,000 c.f.s. without any water passing through the power houses. The maximum amount of flood of record on the St. Lawrence is 307,000 c.f.s.

It will be observed that each of the ten-foot piers extends upstream from the dam 43 feet, to act as an ice breaker upon which heavy field ice may be crowded until broken up and carried through the fifty-foot openings.

Our general plans for this work call for an extended heating system as may be noted on the perspective drawing. This heating system is divided into four separate units and the heat will be supplied either by oil or by electricity as occasion requires. The purpose of this heating system is to give to all masonry and steel work around the gate system, a sufficient amount of heat (probably one-half to one degree Fahrenheit) to prevent the formation of ice on the gates, the gate seats, or any part of the masonry where ice could interfere with the positive and immediate operation of these gates as and when they are required for pool level regulation.

This same heating system is designed to heat the main dam superstructure gate room and thus assure perfect operating conditions.

The introduction of heat as above specified is an innovation in engineering design, but its usefulness and simplicity are both so obvious as not to require any argument for its adoption.

Plate 10070

Plate 10070, page 43, shows a typical wheel setting with its generator. The capacity of the generators and wheels has been assumed at 17,000 horse power, each power station to contain 36 of such units. The above extra capacity of more than 100,000 horse power over 500,000 horse power, is to take care of power demands when in seasons of flood the operating head is reduced below 40 feet.

All of the work herein shown including the power house superstructure has been designed without the use of reinforced concrete except in the transformer, switch

and bus rooms. The entire structure otherwise will be built of mass concrete depending upon its own weight for stability.

Plate 10075

Plate 10075, page 44, shows the location of the cofferdam cribs, the general amount of excavation that will be necessary and the profile of the rock as it was encountered for the 2750 feet of length of the main dam.

Plate 10074

Plate 10074, page 45, shows plans and elevations of the square timber cofferdam cribs that will be required to handle the heavy construction burdens imposed by the work of uncovering rock 70 feet below normal surfaces. It will be observed that in certain locations the cofferdams, in order to take care of the extra heads due to high water and the diversion of the water from its natural channel, will be 95 feet high.

Plate 3468

Plate 3468, page 46, shows a careful comparison between the existing methods of overcoming 224 feet of slope in the St. Lawrence River between Lake Ontario and Montreal and the method here proposed. It will be observed that in the proposed method, five dams will be required, developing a total operating head of about 196 feet. In order to maintain a 30-foot channel after the construction of these dams, the bed of the river will require excavating to whatever cross section the Governments specify as necessary for the 30-foot channel. The excavations coming as they do in the shallow sections of the river and not in the deep sections, can always be accomplished as easily after the dams are constructed as they can before the dams are built.

It will be noticed that the construction of Dams Nos. 3 and 4 will require the removal of the power plant of the Cedar Rapids Power Company, the Soulanges Canal plant and the Canadian Beauharnois Power Company's plant.

As and when market conditions justify, it is entirely probable that the Cedar Rapids Power Company and the interests controlling the Soulanges and Canadian Beauharnois Companies will be found anxious to undertake the financing and construction of Dams Nos. 3 and 4 for their own account, upon terms to be negotiated with the Canadian Government.

In our consideration of this problem we have assumed that in advance of construction of either of these dams (in the event that the affected power companies are not interested in the new work), definite arrangements would be made with the owners of these plans whereby before their operation was interfered with and

continuing thereafter for the full term of their then existing rights, these plants would receive from the substituting power installations, and as a charge against the same, the amount of horse power they are then developing, under terms that could in no way be considered as curtailing or invading vested rights.

It will not be claimed by the owners of these plants that their existing use of 160,000 horse power should ever be allowed to act as a bar to supplying a public need for power up to 2,000,000 horse power.

A similar observation can be made as to Dam No. 5 which will do away with the Lachine Rapids power plant, but as this plant is very small in capacity, the same provisions with respect to substitute power from the new plant will undoubtedly be found acceptable to the owners of the Lachine Company.

No careful investigations were made with reference to the manner of passing navigation from Elevation 20.00 at Montreal to Elevation approximately 33.00, but it is assumed that one lock would be sufficient for this transfer.

14. ATTITUDE OF THE STATE AND CITY OF NEW YORK

At various times before the Commission representatives of the State and City of New York have made extended arguments against any proposal to improve navigation in the St. Lawrence. This opposition has been based upon the theory that such an improvement would, on the one hand, make the Erie Canal useless, and on the other would divert so large an amount of tonnage by way of Montreal as to seriously affect the importance of the Port of New York.

We do not believe these arguments will be reiterated after the serious minded men, who have made them, are correctly informed as to the importance of water power to the State and City of New York. The general values incident to water power development accruing to the State and City of New York have been set forth in Section 9, and we believe it will be of some assistance to the Commission if we make the following statement with respect to the Erie Canal.

The Erie Canal is 356 miles long and this barge system has cost up to date $155,000,000.00 excluding interest. At no time in its 20-year operating history has the tonnage over the Canal system even approximately justified this vast expenditure. The cost of the Erie Canal for 1919 to the taxpayers of the State including interest was approximately $6,000,000.00. The total freight movement over the Canal for this period was 730,000 tons, about 45 per cent of which was sand and gravel. The taxpayers of the State paid at the rate of $8.00 a ton for the transport of this sand and gravel, the average selling price of which was not even $4.00 per ton.

If the sand and gravel and other similar commodities were charged a rate for the use of the Canal the traffic should bear, then we would have in this record about

$5,500,000.00 of costs in 1919 to be absorbed by less than 300,000 tons of high grade freight including wheat. This division would result in a charge against the taxpayers for the use of the Canal of over $18.00 a ton for the high grade freight movement. Eighteen dollars a ton is 55 cents a bushel on wheat. The present rail rate on wheat between Buffalo and New York is 14.4 cents per bushel.

The above sums paid by the taxpayers are exclusive of the actual costs of transporting the commodities enumerated. To those claiming that the Erie Canal is a rate fixing agency, the obvious reply is that the Interstate Commerce Commission is, and for a long time past has been, fixing all freight rates. It is unreasonable, therefore, to conclude from the foregoing that up to date the Erie Canal is a great liability to the State taxpayers, and is it not reasonable to suppose they would welcome any plan that would make an asset of this $155,000,000.00 instead of the liability that it now is?

What the Canal needs in order to handle a tonnage that will make an asset of it to the State is a multitude of sound industries using cheap power distributed throughout its length of 356 miles. An abundance of cheap power combined with attractive water and rail freight rates with nearby ocean traffic facilities will create an industrial installation that can not be otherwise brought into existence. When such an industrial situation is installed and not until then, will the Canal, in our judgment, be worth the money it has cost in the past and will require in the future for its proper maintenance and expansion.

The rational way to accomplish this industrial need and the most powerful agency to that end is undoubtedly hydro-electric power at business getting rates along the whole length of the Canal. The State of New York must depend in a large degree upon the manufacturing industry for its best future growth, and these industries must have "white coal" if they are to compete with the coal fields of Pennsylvania.

15. CONCLUSIONS

In all of the foregoing we have attempted to briefly outline the proposals we have in mind.

We are firmly of the opinion that the public interest, as stated before, requires the use of private initiative and capital to the fullest possible extent. We believe that the Croil Island development and all succeeding developments, both in the United States and in Canada should be entrusted absolutely to private capital and should not be undertaken until private capital is willing to take the risks and responsibilities incident thereto. Any attempt to bring such a plan about by the introduction here and there of government effort on either side of the line, will result in failure in the future just as it has in the past.

We are, however, very certain that human selfishness should not be trusted over long periods of time, and that all large combinations of capital invested in public utilities such as here discussed, should be subject to very strict, thorough and impartial regulation at the hands of public bodies properly and fully compensated for the important responsibilities their offices require them to assume.

At the same time that the public is being protected regarding the rates and service, the public interest will be best served when capital is given its proper consideration. Such consideration will require that investments shall be protected in point of tenure and shall be protected from all forms of vicious attack whether at the hands of dishonest demagogues or ignorant, but otherwise honest, enthusiasts.

Protection to the public and to property alike is one of the fundamental objects of government and indeed this is what government is for.

Outside of the manufacture of explosives, there is probably no form of construction that is more hazardous than hydro-electric work, and this fact should be taken into proper consideration when hydro-electric developments are under discussion and decision.

The United States Congress in handling the recently passed water power law after a discussion of its terms over ten years, has provided methods whereby the public and capital can be brought together in a perfectly logical and clearly understood relationship to one another.

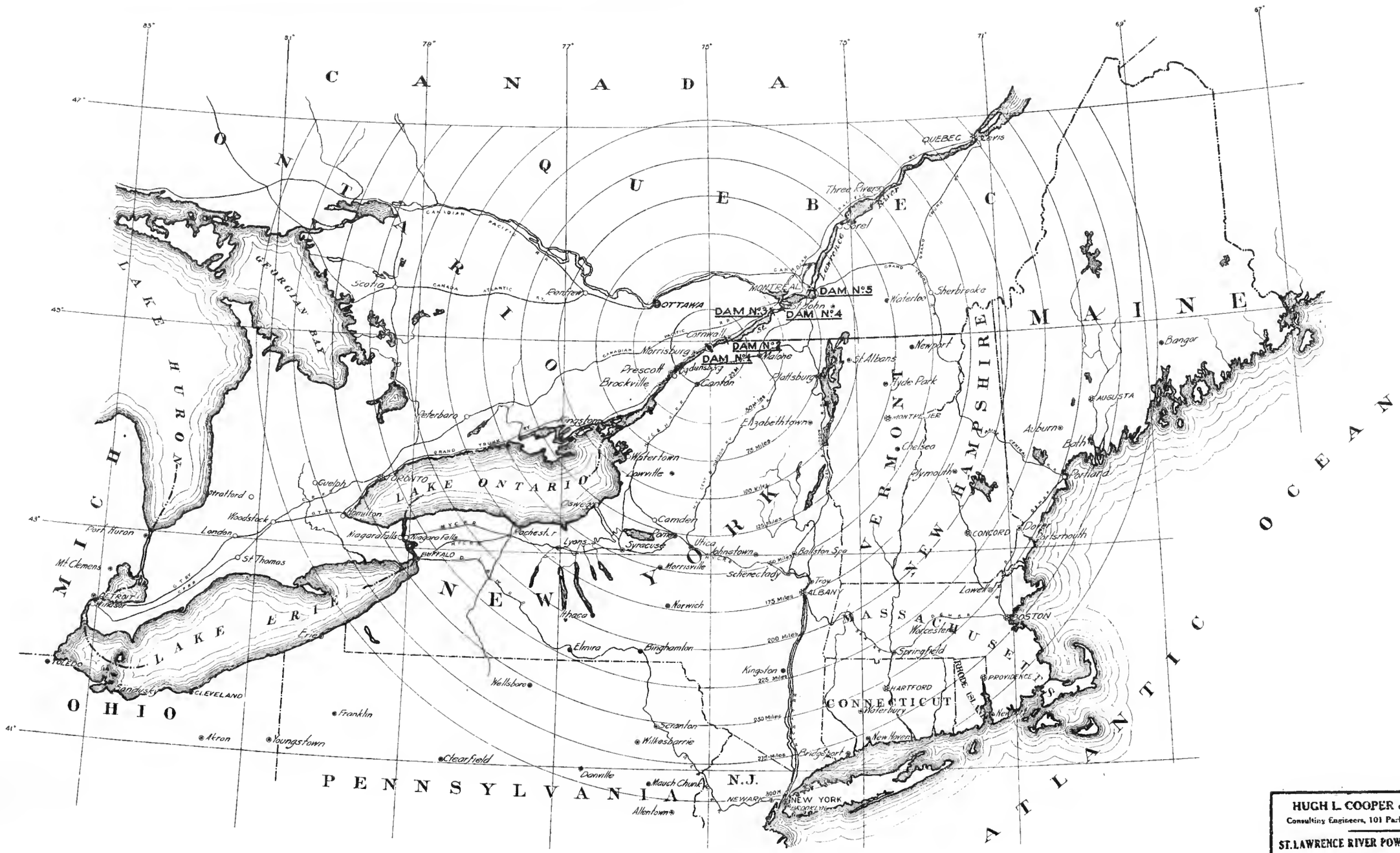
The great importance of navigation to Canada in particular and to the United States in general, is so great that in the plans for the development of any water power on the St. Lawrence, the regulation dams and their operation should be left entirely with the Governments.

We are certain that no plan for the reconstruction of the St. Lawrence River will ever be adopted that is not really in the best public interest. Private capital will never invest in a water power or any other form of construction on the St. Lawrence or elsewhere unless, after exhaustive study, the project is known to be really in the best interest of the general public, because such investment would be neither safe nor wise.

We shall be very glad to appear before you at any time for any consultation you may hereafter find desirable.

If the Commission finds need of data in addition to that here submitted, the same will be promptly supplied upon request, if in our possession.

HUGH L. COOPER & CO.



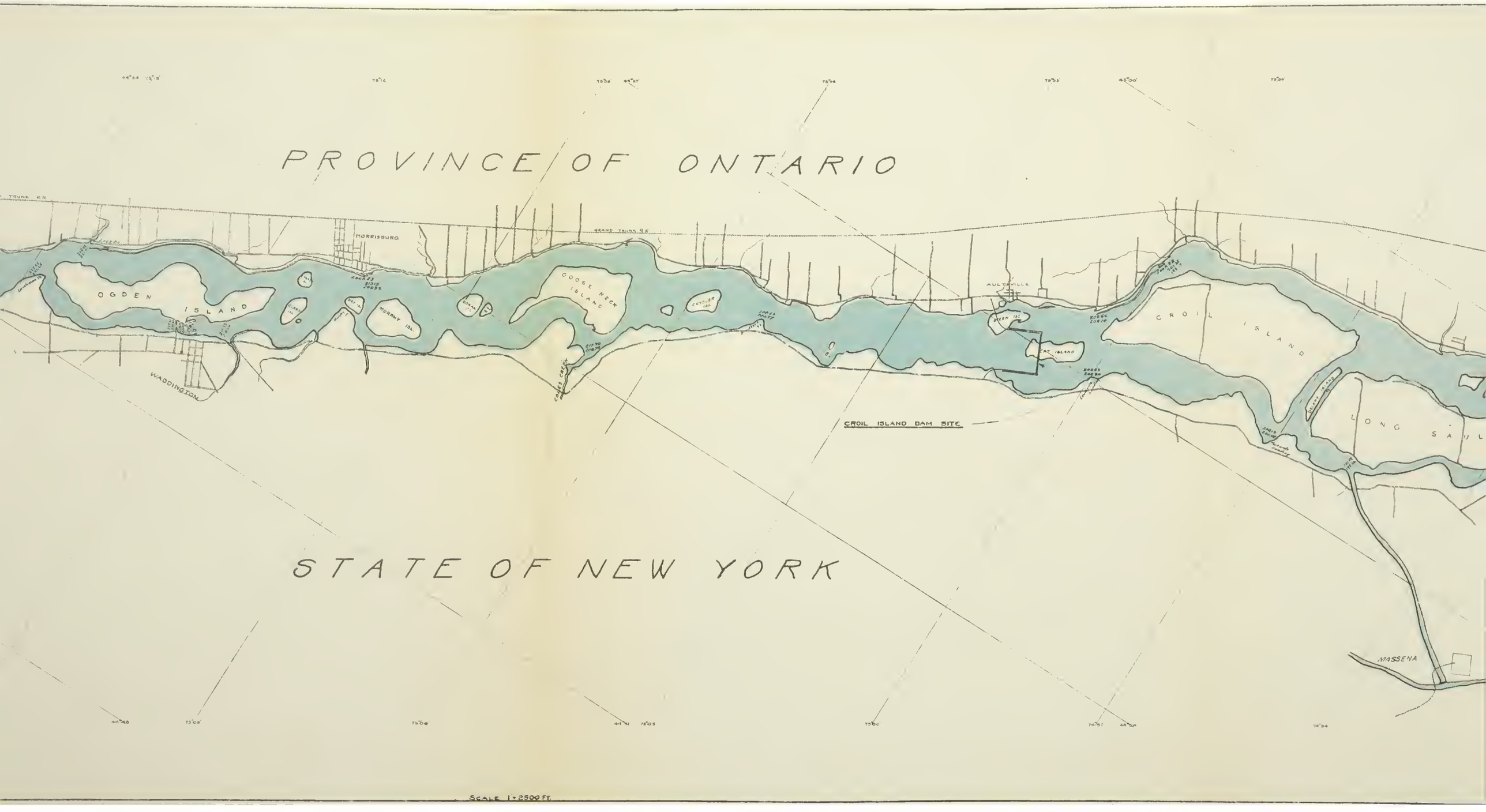
HUGH L. COOPER & COMPANY
Consulting Engineers, 101 Park Avenue New York

ST. LAWRENCE RIVER POWER DEVELOPMENT

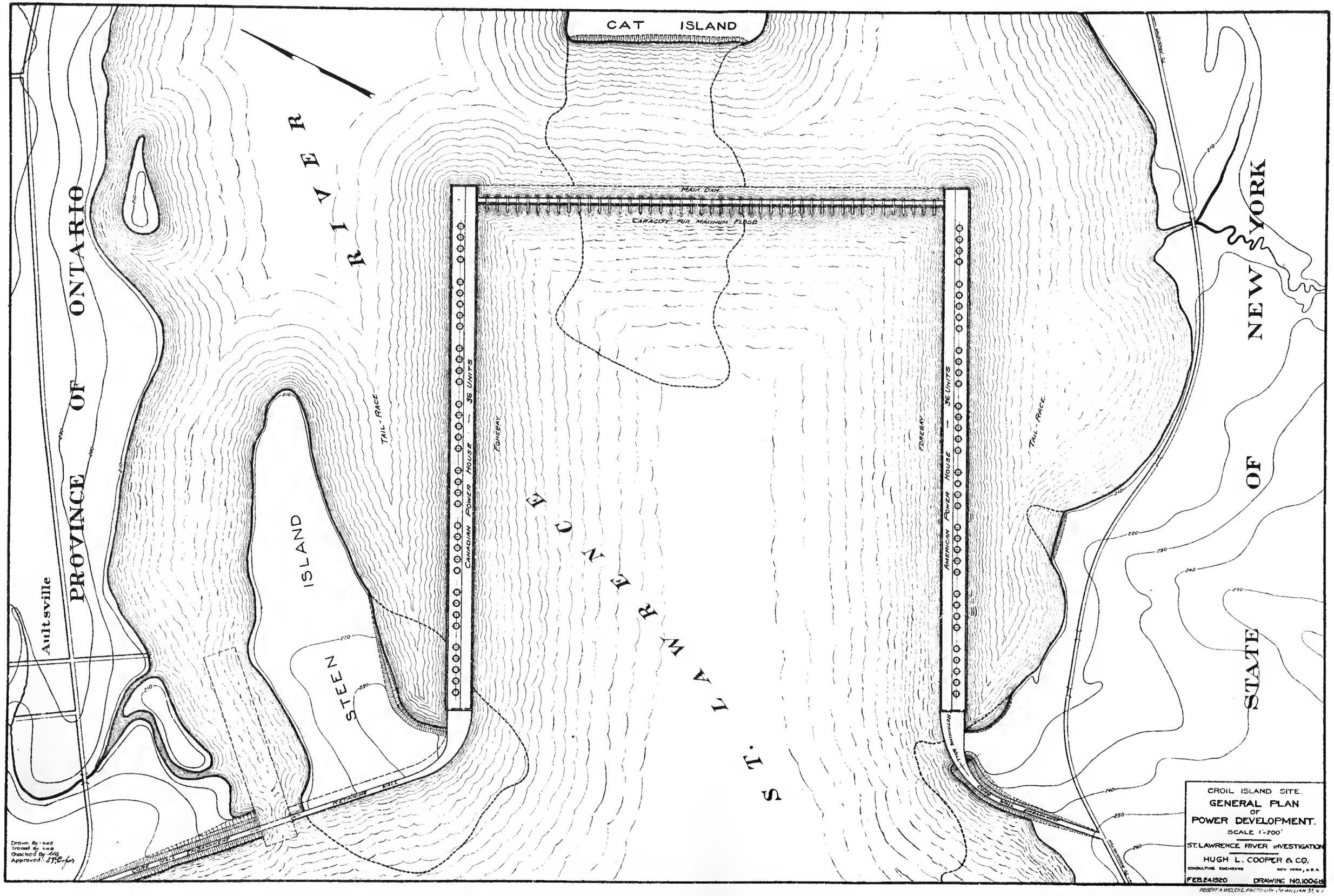
Proposed International Power Development
St. Lawrence River near Croil Island
GEOGRAPHICAL LOCATION

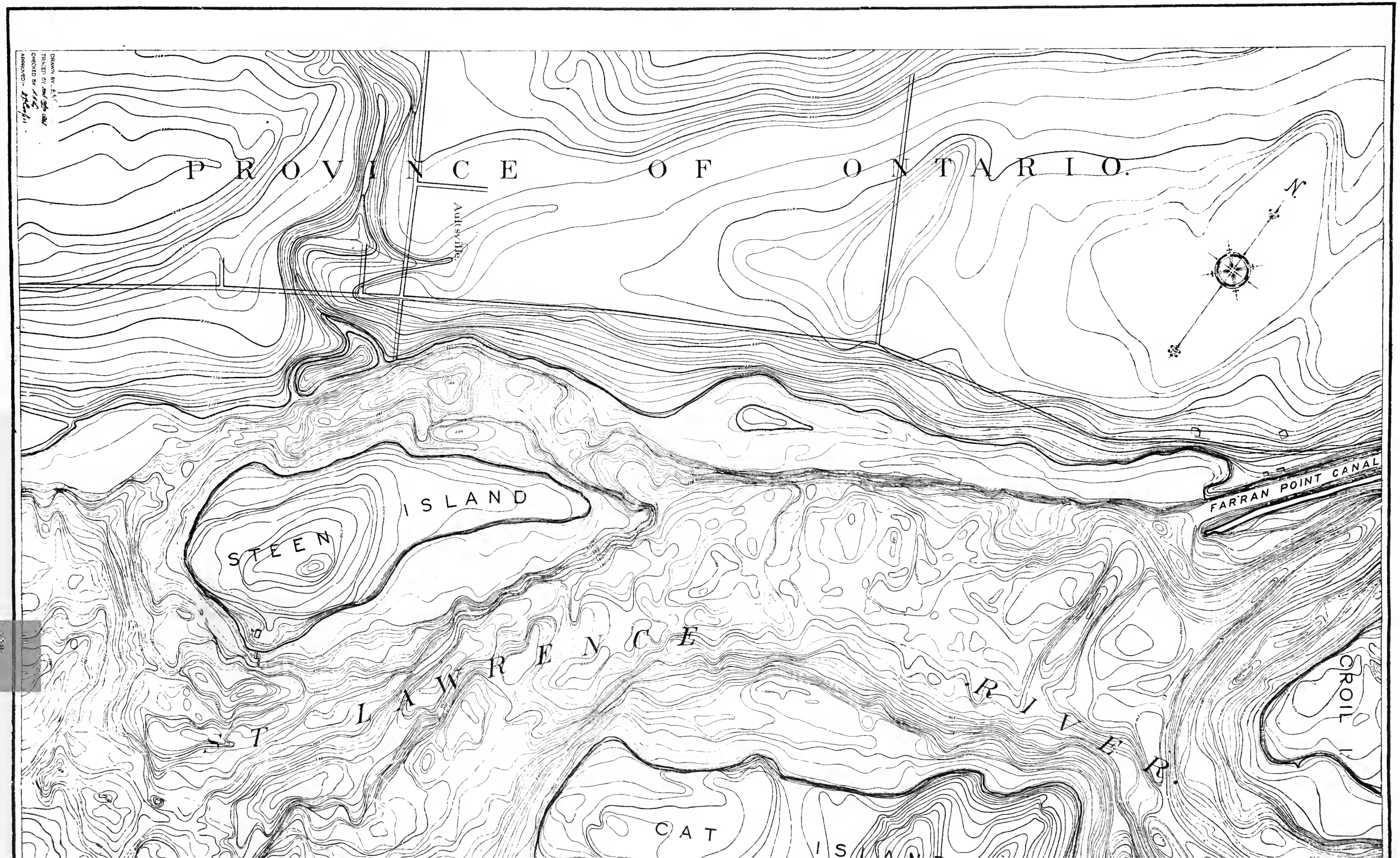
Date: November 11, 1920 Scale: 1 inch = 37 miles.
Revisions:
File No. Drawing No. 3461

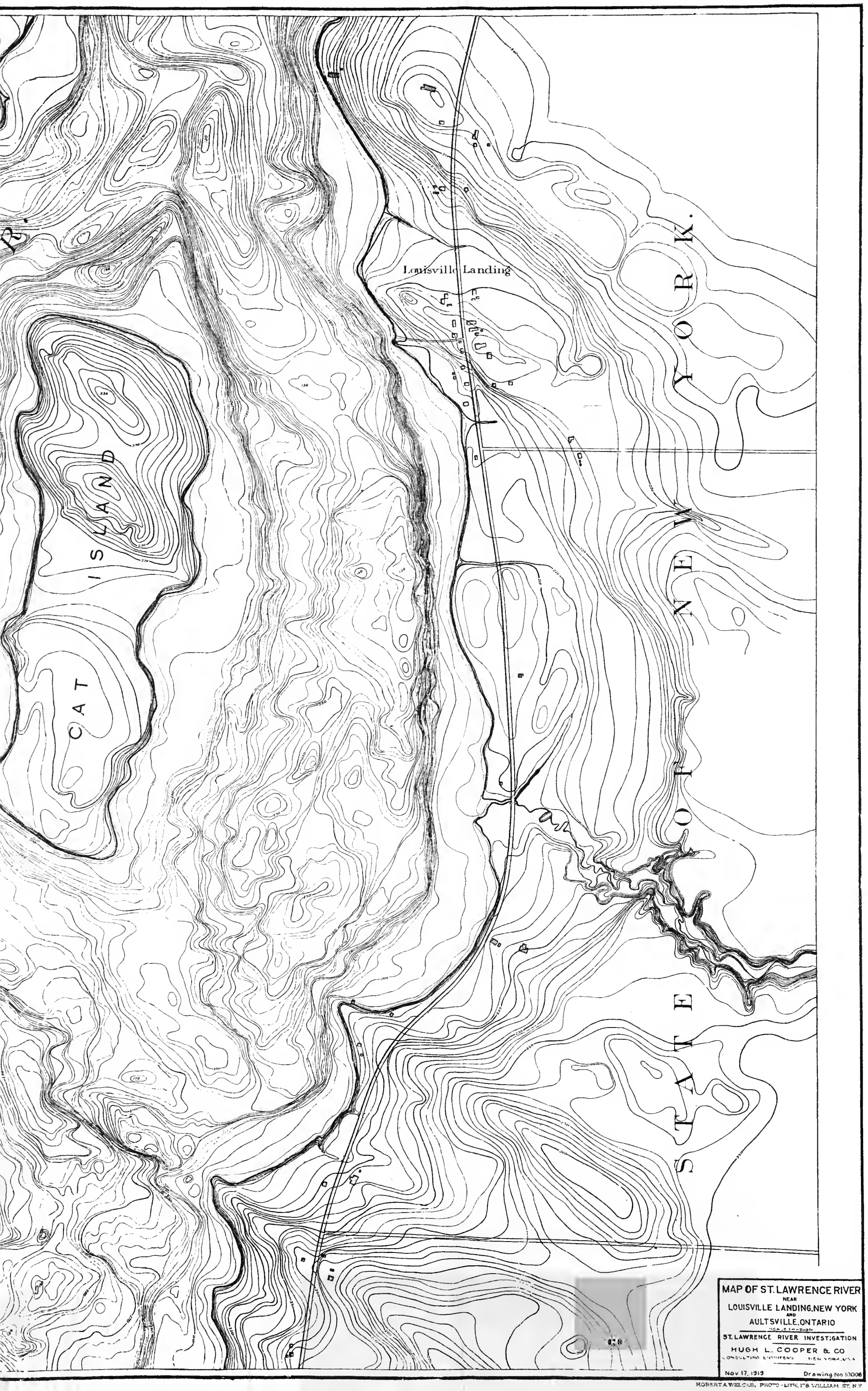
ROBERT A. WELCHE PHOTO-LITH, 176 WILLIAM ST. N.Y.


PROVINCE OF ONTARIO
STATE OF NEW YORK
MORRISBURG
GRAND TRUNK R.R.
OGDEN ISLAND
WADDINGTON
MURPHY ISL.
GOOSE NECK ISLAND
CHYDLER ISL.
AULTSVILLE
CROIL ISLAND
LONG SAUL
CROIL ISLAND DAM SITE
MASSENA
SCALE 1"=2500 FT.

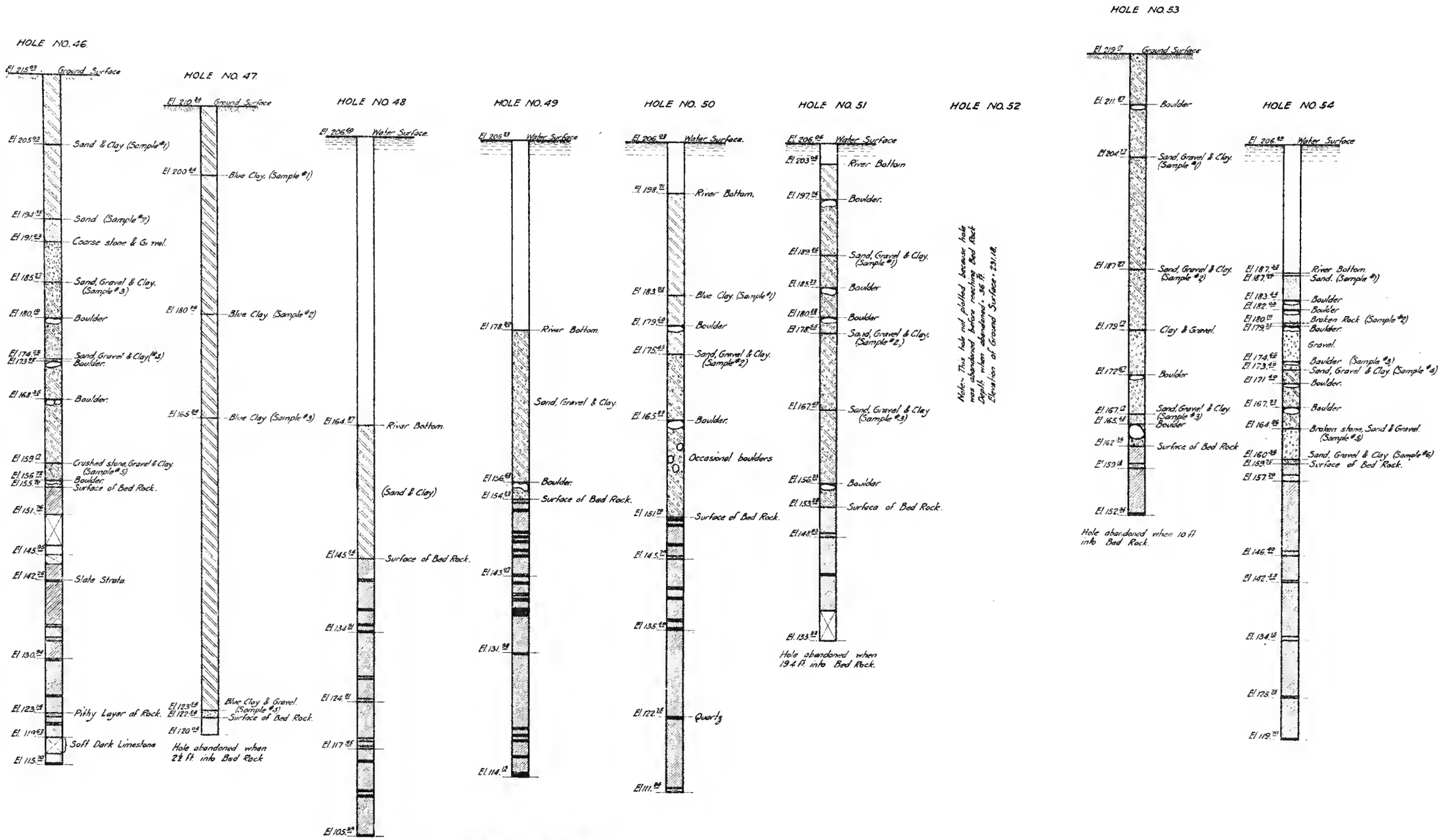
ROBERT A. WELCH, PHOTO-LITH 175 WILLIAM ST. N.Y.


CAT ISLAND
MAIN DAM
CAPACITY FOR MAXIMUM FLOOD
PROVINCE OF ONTARIO
Aultsville
STEEN ISLAND
RIVER
ST. LAWRENCE
STATE OF NEW YORK
CANADIAN POWER HOUSE — 36 UNITS
AMERICAN POWER HOUSE — 36 UNITS
FOREBAY
TAIL-RACE
RETAINING WALL
CROIL ISLAND SITE.
GENERAL PLAN
OF
POWER DEVELOPMENT.
SCALE 1"=200'
ST. LAWRENCE RIVER INVESTIGATION
HUGH L. COOPER & CO.
CONSULTING ENGINEERS
NEW YORK, U.S.A.
FEB. 24 1920
DRAWING NO. 10068
ROBERT A. WELCKE, PHOTO-LITH 178 WILLIAM ST. N.Y.


DRAWN BY
TRACED BY
CHECKED BY
APPROVED
PROVINCE OF ONTARIO.
Aultsville
N.
STEEN ISLAND
FARRAN POINT CANAL
ST. LAWRENCE RIVER.
CROIL I.
CAT ISLAND



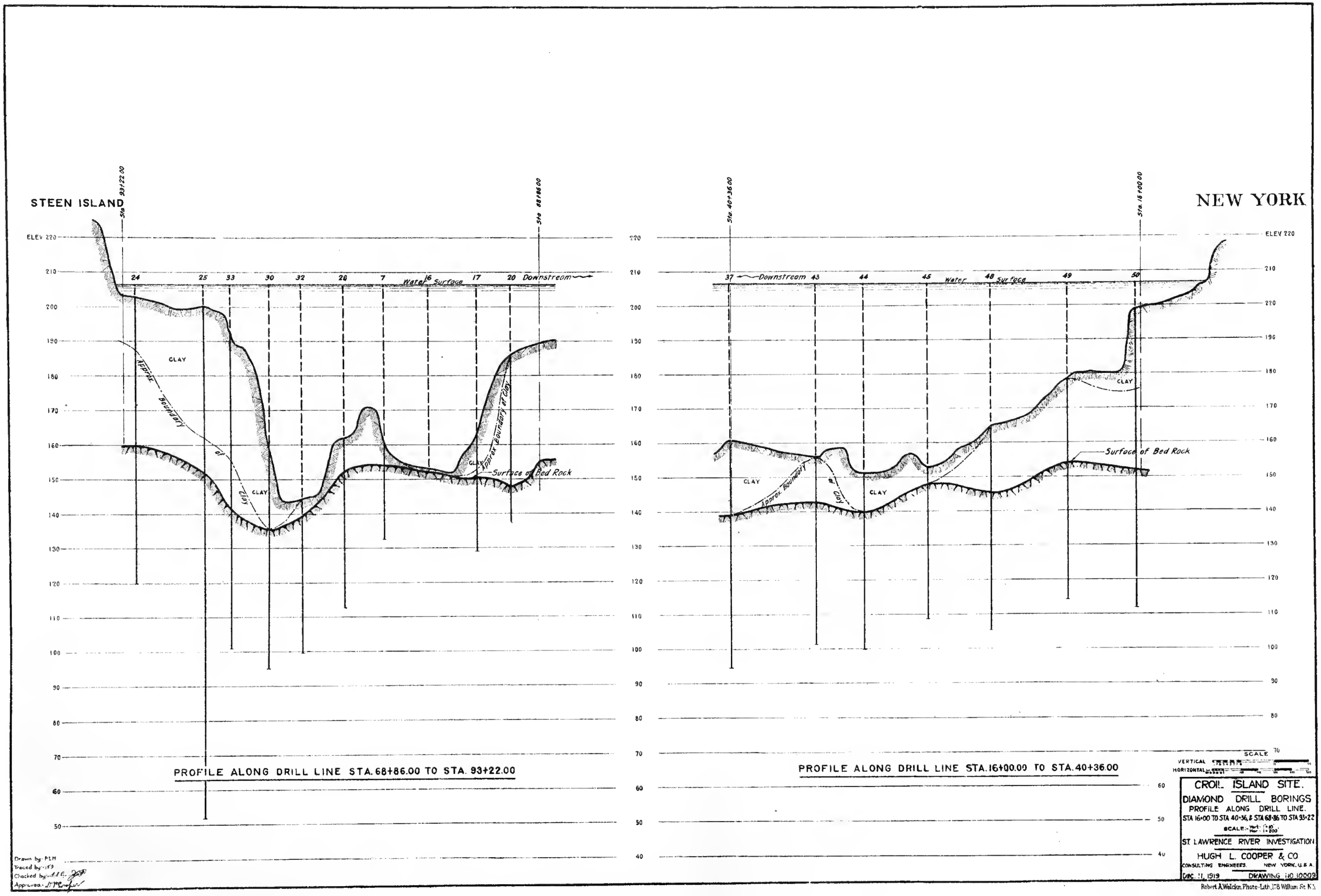
ROBERT A. WELCKE, PHOTO-LITH. 178 WILLIAM ST. N.Y.

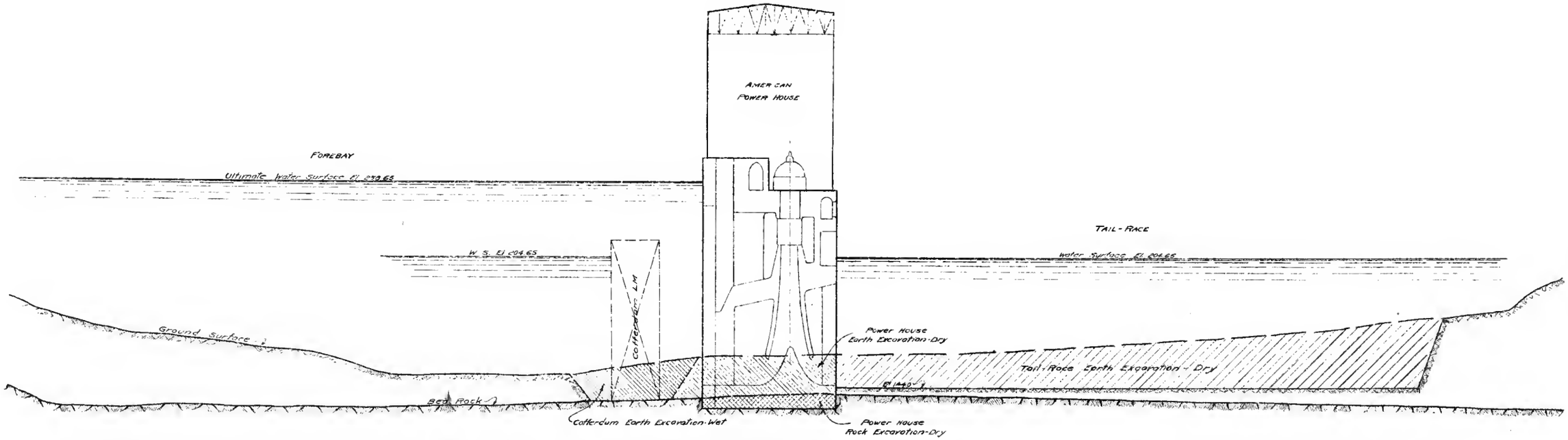


Drawn by:- R.A.S.
Traced by:- R.A.S.
Checked by:- R.L.S.
Approved.

CROIL ISLAND SITE.
DIAMOND DRILL BORINGS, DETAILS.
HOLES NO. 46-54, INCLUSIVE.
SCALE:- 1"=6'-0"
ST. LAWRENCE RIVER INVESTIGATION.
HUGH L. COOPER & CO.
CONSULTING ENGINEERS NEW YORK U.S.A.
Nov. 28, 1919 DRAWING NO. 10016

Robert A. Welcke-Photo-Lith, 178 William St. N.Y.

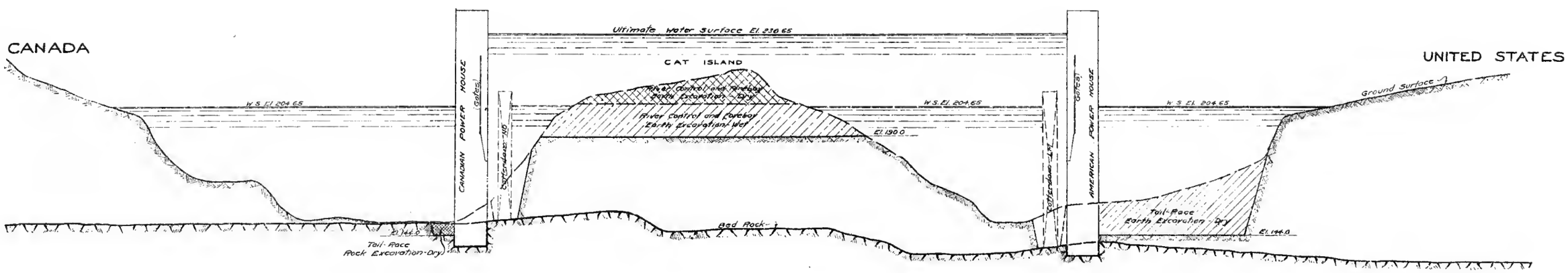

STEEN ISLAND
NEW YORK
Sta. 93+22.00
Sta. 68+86.00
Sta. 40+36.00
Sta. 16+00.00
ELEV 220
Water Surface
Downstream
CLAY
Approx. Boundary of Clay
Surface of Bed Rock
PROFILE ALONG DRILL LINE STA. 68+86.00 TO STA. 93+22.00
PROFILE ALONG DRILL LINE STA. 16+00.00 TO STA. 40+36.00
SCALE
VERTICAL
HORIZONTAL
CROIL ISLAND SITE.
DIAMOND DRILL BORINGS
PROFILE ALONG DRILL LINE.
STA 16+00 TO STA 40+36, & STA 68+86 TO STA 93+22
SCALE:- Vert: 1"=10' Hor: 1"=200'
ST. LAWRENCE RIVER INVESTIGATION
HUGH L. COOPER & CO
CONSULTING ENGINEERS. NEW YORK, U.S.A.
DEC. 11, 1919
DRAWING NO. 10003
Drawn by: FLM
Traced by: 159
Checked by:
Approved:
Robert A. Welcke, Photo-Lith, 178 William St. N.Y.



POWER HOUSE & COFFERDAM EXCAVATION

Scale { Hor 1" = 50' Vert 1" = 20'

Note:
Under "River Control and Forebay Excavation" is understood the excavation which is necessary for controlling the river during the second period of construction, when the river will flow between the two power house cofferdams and through the main dam.
For Q = 300,000 c.f.s. - velocity in forebay during operation equals 2.5 feet per second, and during construction 5 feet per second



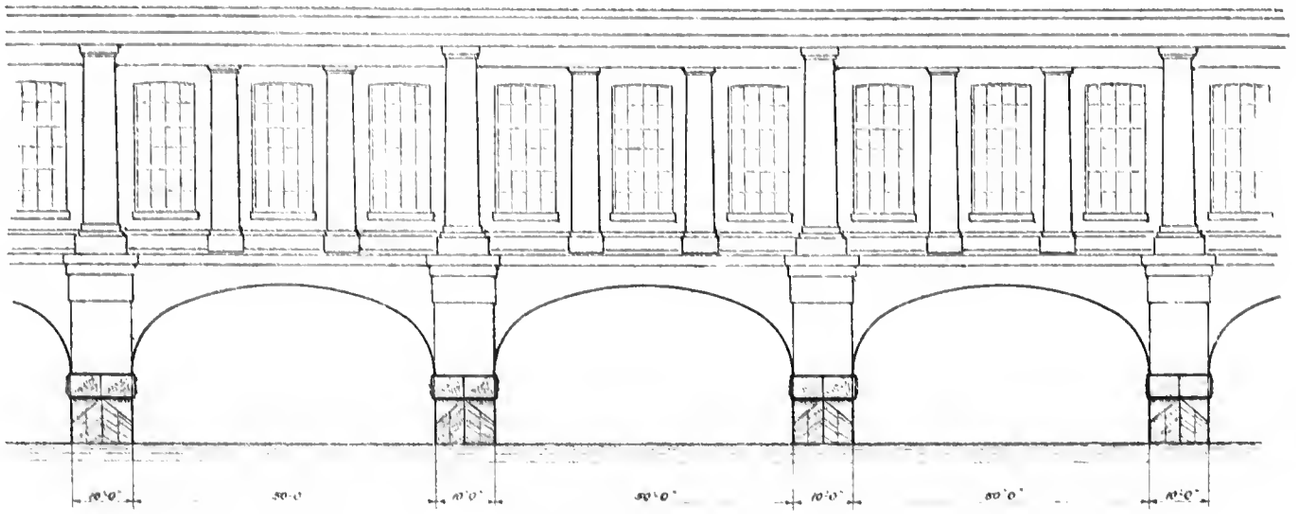
CROSS SECTION OF FOREBAY & TAIL-RACES

(Section X X. See Drawing No 10073)

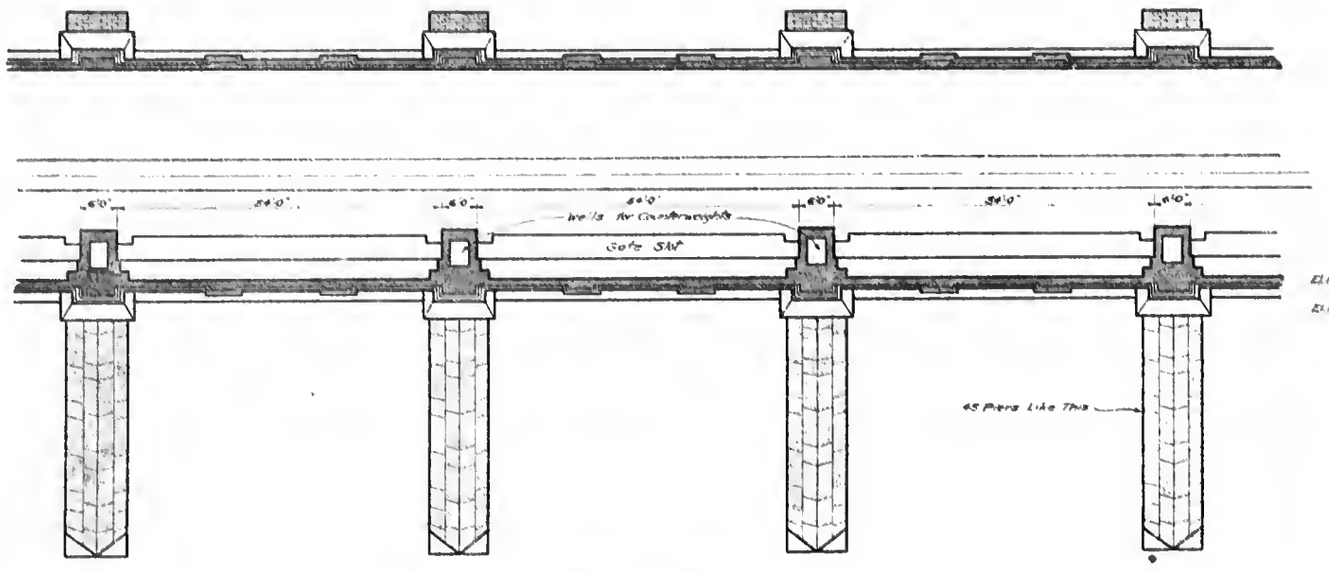
Scale { Hor 1" = 200' Vert 1" = 20'

CROIL ISLAND SITE
PLAN OF WATER CONTROL AND FOREBAY EXCAVATION.
SCALES AS SHOWN
ST LAWRENCE RIVER INVESTIGATION
HUGH L. COOPER & CO.
CONSULTING ENGINEERS. NEW YORK, U.S.A.
FEB. 21, 1920. DRAWING NO. 10076

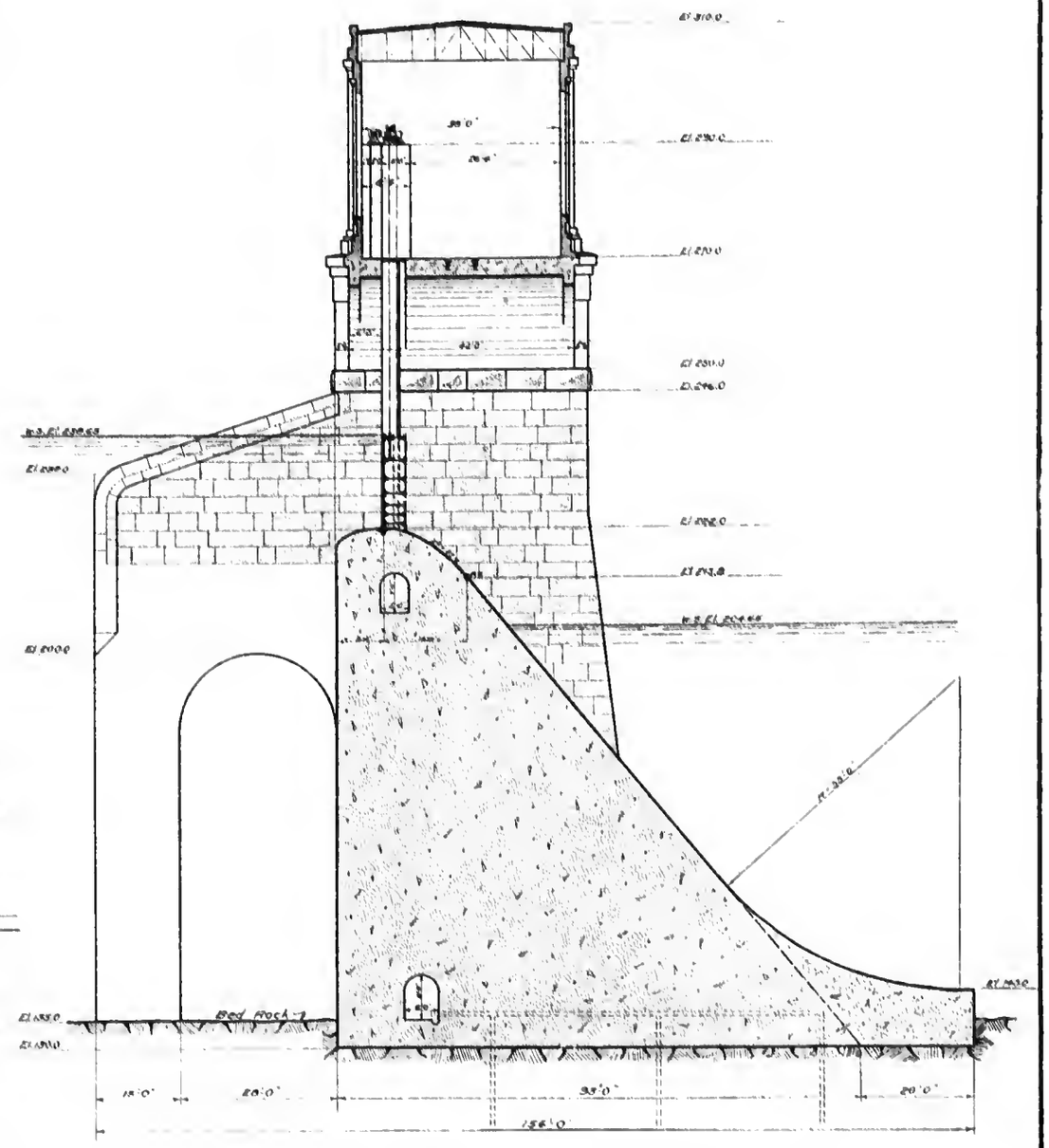
ROBERT A. WELCKE PHOTO LITH. 178 WILLIAM ST. N.Y.



UPSTREAM ELEVATION



PLAN VIEW
(Spillway Section Removed)

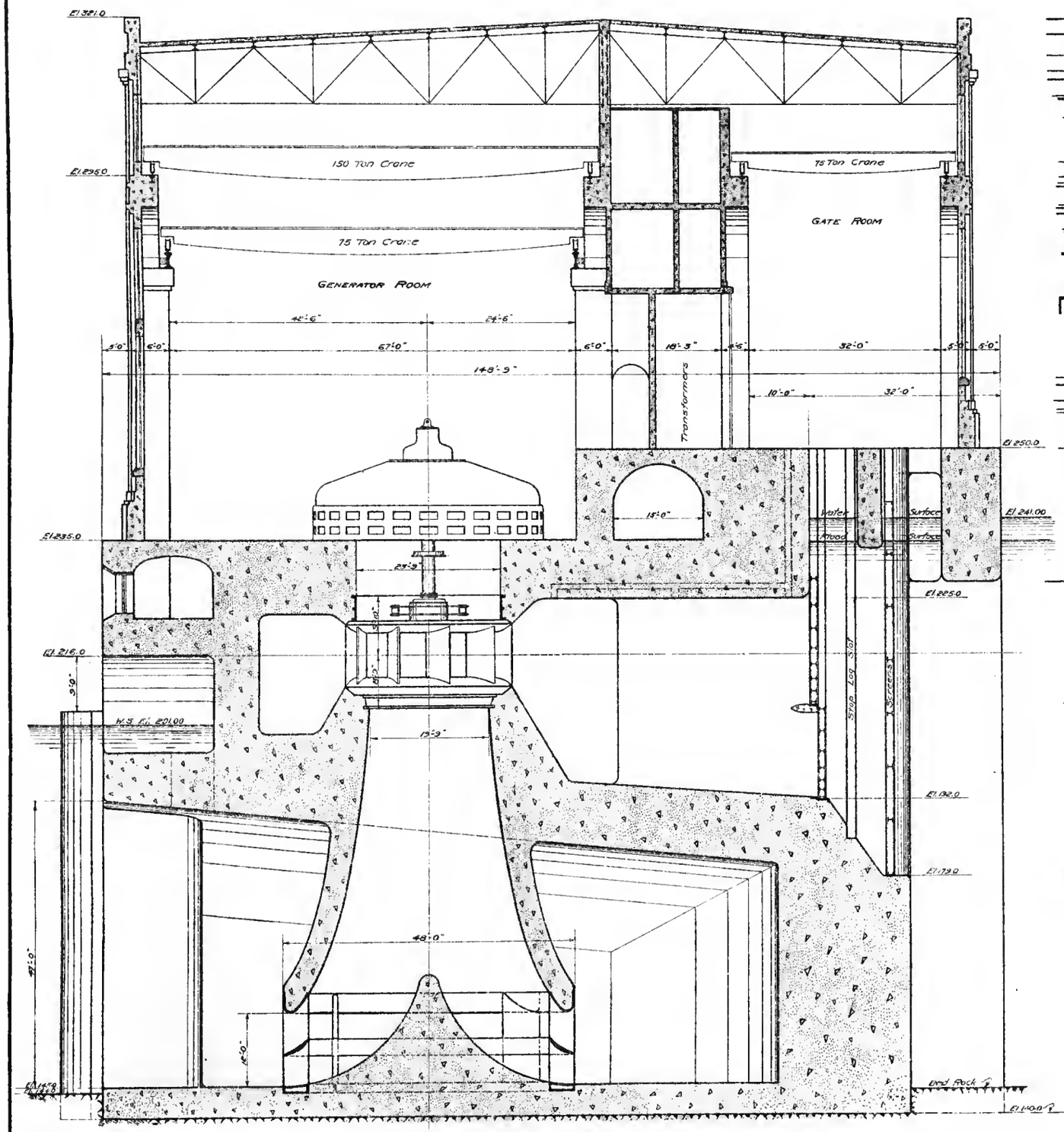


CROSS SECTION

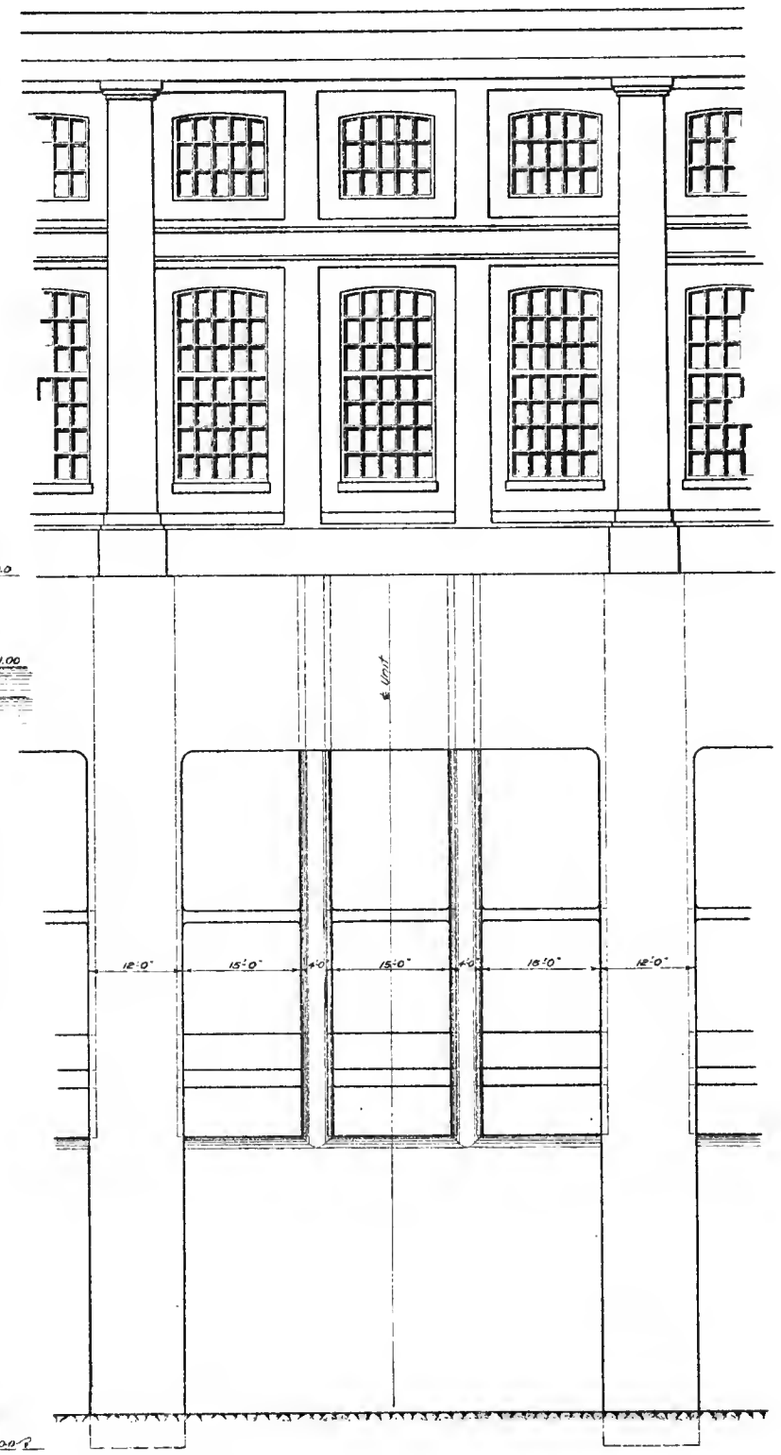
Drawn By: W
Traced By: W
Checked By: [illegible]
Approved: [illegible]

CROIL ISLAND SITE
CROSS SECTION
OF
MAIN DAM.
SCALE 3/32"=1'-0"
ST. LAWRENCE RIVER INVESTIGATION
HUGH L. COOPER & CO.
CONSULTING ENGINEERS NEW YORK, U.S.A.
FEB. 19, 1920. DRAWING NO. 100[illegible]

Robert A. Welcker Photo Lith. 178 William St. N.Y.



CROSS SECTION THROUGH UNIT.



UPSTREAM ELEVATION.

Drawn by H.K.P.
Traced by L.W.P.
Checked by H.L.C.
Approved: H.L. Cooper

CROIL ISLAND SITE.

CROSS SECTION OF POWER HOUSE.

SCALE $\frac{1}{8}$"=1'-0"

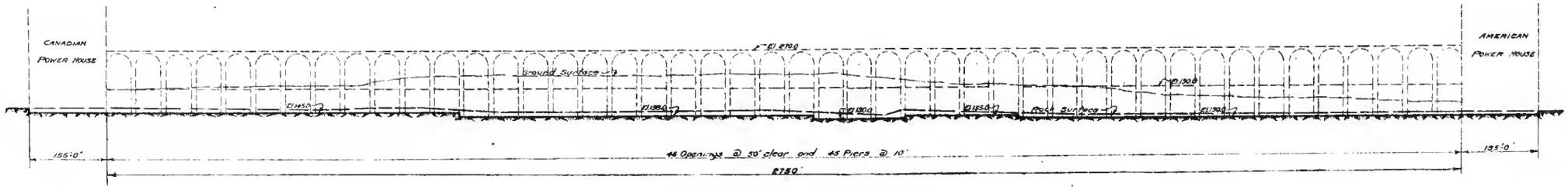
ST. LAWRENCE RIVER INVESTIGATION

HUGH L. COOPER & CO.

CONSULTING ENGINEERS. NEW YORK, U.S.A.

FEB 23, 1920. DRAWING NO. 10070

ROBERT A. WELCKE PHOTO-LITH, 178 WILLIAM ST. N.Y.



ELEVATION OF MAIN DAM

Scale 1"=100'

NOTE-A

Where "Wet Excavation" is indicated the river bed must be removed to solid rock by dredging to permit of placing the cofferdams on the solid rock

After the cofferdams are in place and pumped out the zone marked "Dry Excavation" is to be removed by steam shovel.

NOTE-B-

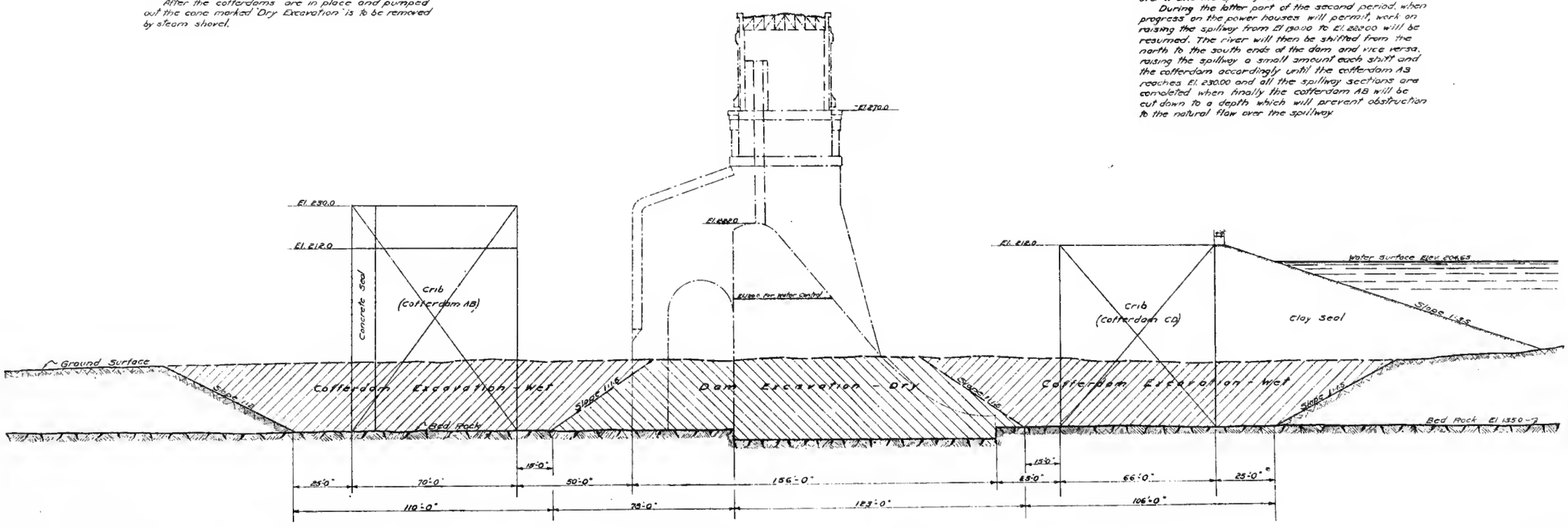
The cofferdam "AB" is to serve thru both the first and second periods of construction, while the cofferdam "CD" is to serve thru the first period only.

"AB" therefore, is to be built to El. 212.00 for the first period and the river diverted to the north and south channels.

During the second period the river is to be confined between the two power house cofferdams and to discharge over the spillway at El. 130.00

In order that this plan may be effective, "AB" must be cut down to El. 130.00 and decked over, the river flowing over it and the spillway at El. 130.00

During the latter part of the second period, when progress on the power houses will permit, work on raising the spillway from El. 130.00 to El. 220.00 will be resumed. The river will then be shifted from the north to the south ends of the dam and vice versa, raising the spillway a small amount each shift and the cofferdam accordingly until the cofferdam AB reaches El. 230.00 and all the spillway sections are completed when finally the cofferdam AB will be cut down to a depth which will prevent obstruction to the natural flow over the spillway



CROSS SECTION OF EXCAVATION

Scale 1"=20'.

(Section Y-Y See Drawing No. 10073)

Note:
For Details of Cribs
See Drawing No. 10074

CROIL ISLAND SITE.

PLAN OF EXCAVATION FOR MAIN DAM.

SCALES AS SHOWN

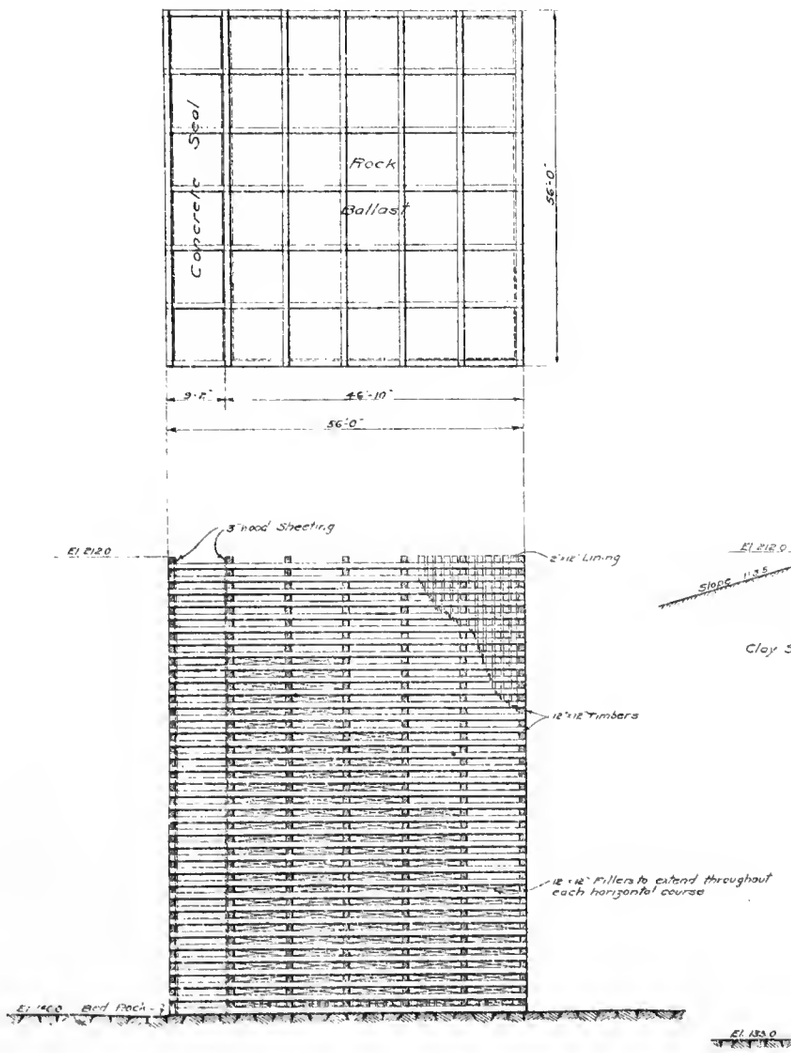
ST. LAWRENCE RIVER INVESTIGATION

HUGH L. COOPER & CO.
CONSULTING ENGINEERS NEW YORK, U.S.A.

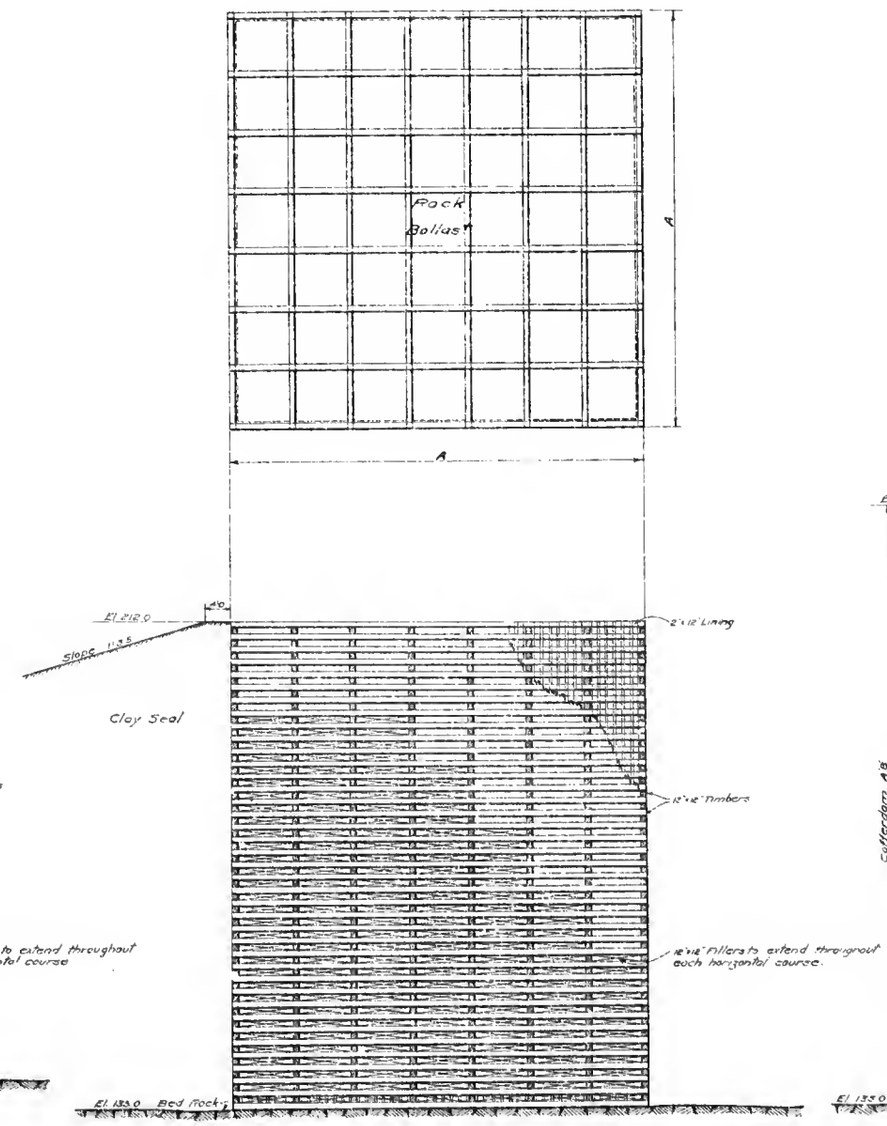
FEB. 20, 1920. DRAWING NO. 10075

Drawn By - W.S.P.
Traced By - M.R.
Checked By - [illegible]
Approved - [illegible]

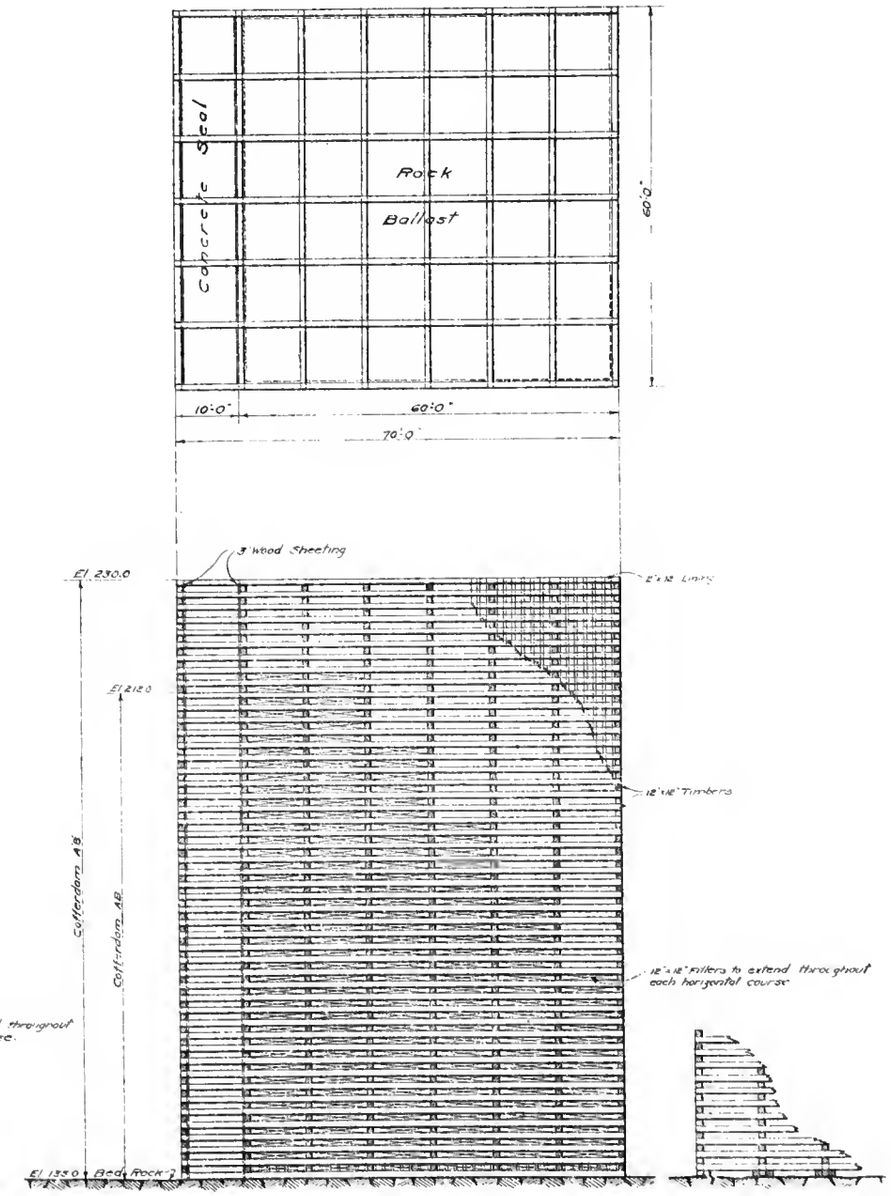
Robert A. Weicke, Photo-Lith, 178 William St. N.Y.



COFFERDAMS LM, NO, AD AND BC



COFFERDAMS CD, DE, CJK, FG AND HI



COFFERDAMS AB AND A'B'

TABLE OF DIMENSIONS

Cofferdam	Lowest Elev. of Bed Rock	A	Number of Pieces
CD	135.0	66'-0"	49
DE	122.0	73'-6"	49
CJK	156.0	40'-0"	25
FG	136.0	48'-0"	25
HI	160.0	44'-0"	16

Drawn By
Traced By
Checked By
Approved

CROIL ISLAND SITE

DETAILS OF COFFERDAM CRIBS.

SCALE 1" = 10'-0"

ST. LAWRENCE RIVER INVESTIGATION

HUGH L. COOPER & CO.

CONSULTING ENGINEERS NEW YORK, U.S.A.

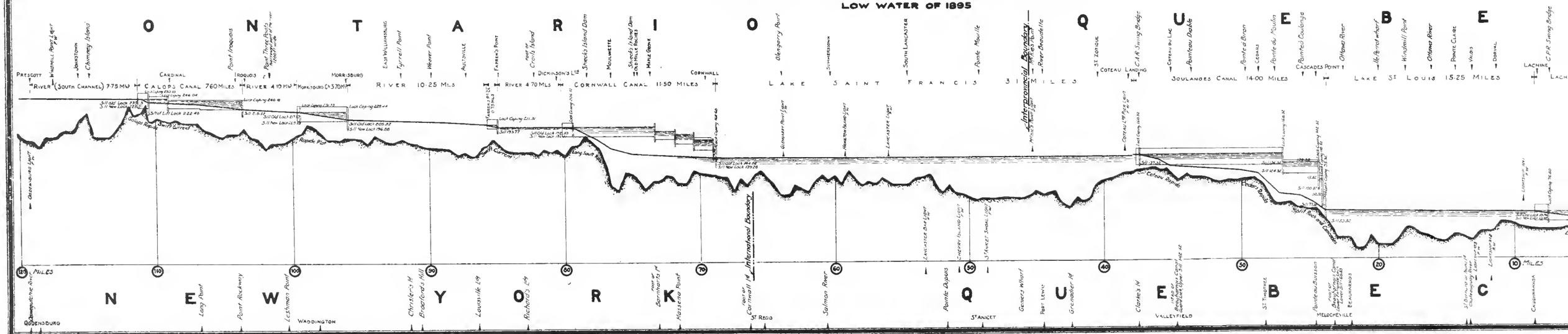
FEB 18 1920 DRAWING NO. 10074

EXISTING PROFILE OF ST LAWRENCE RIVER

BETWEEN LAKE ONTARIO LEVEL AT OGDENSBURG AND MONTREAL.

LOW WATER OF 1895

Pool levels shown are extreme low water levels.



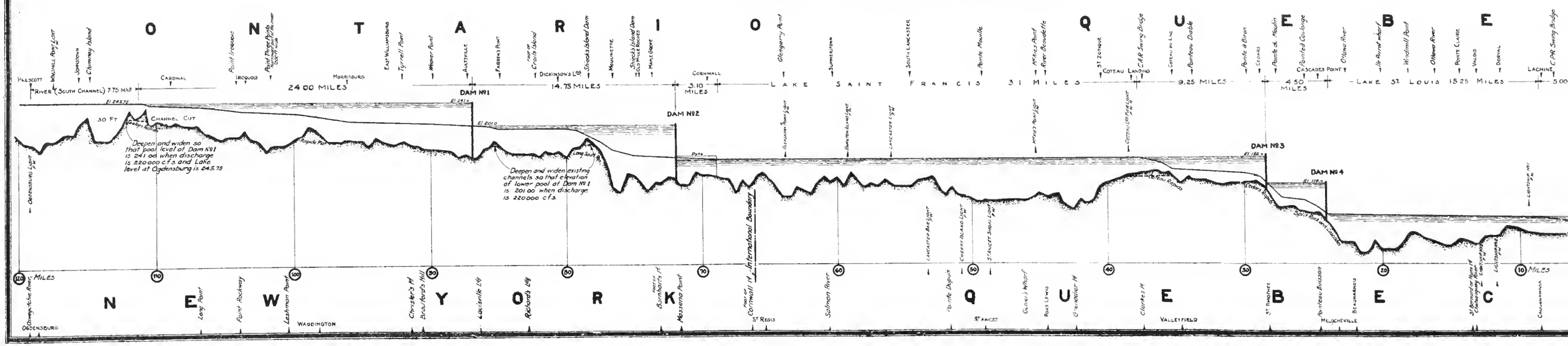
MINIMUM RECOMMENDED PROFILE OF ST LAWRENCE RIVER

BETWEEN LAKE ONTARIO LEVEL AT OGDENSBURG AND MONTREAL

DEVELOPED FOR

POWER & NAVIGATION PURPOSES.

Pool levels shown are approximate for a mean stage discharge of 220000 c

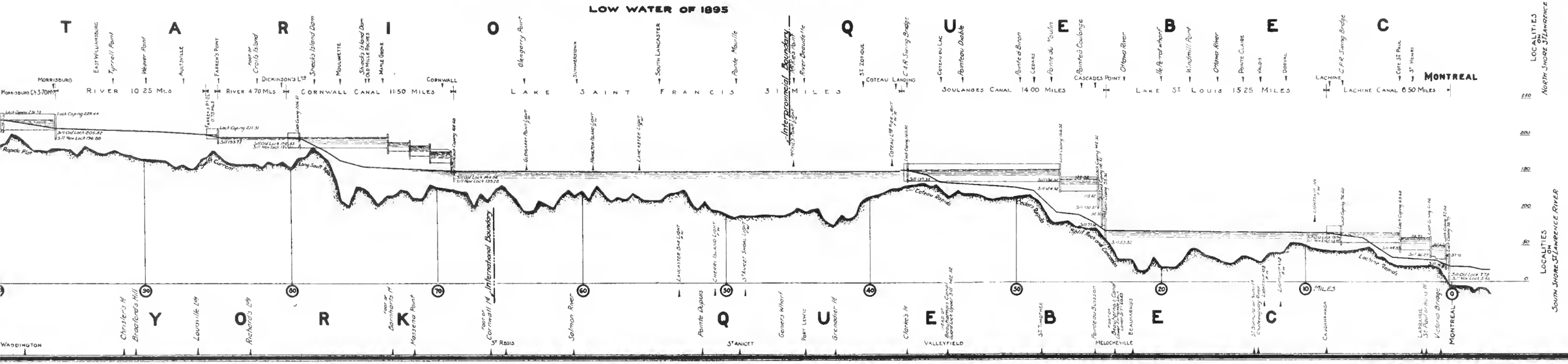


EXISTING PROFILE OF ST LAWRENCE RIVER

BETWEEN LAKE ONTARIO LEVEL AT OGDENSBURG AND MONTREAL.

LOW WATER OF 1895

Pool levels shown are extreme low water levels.



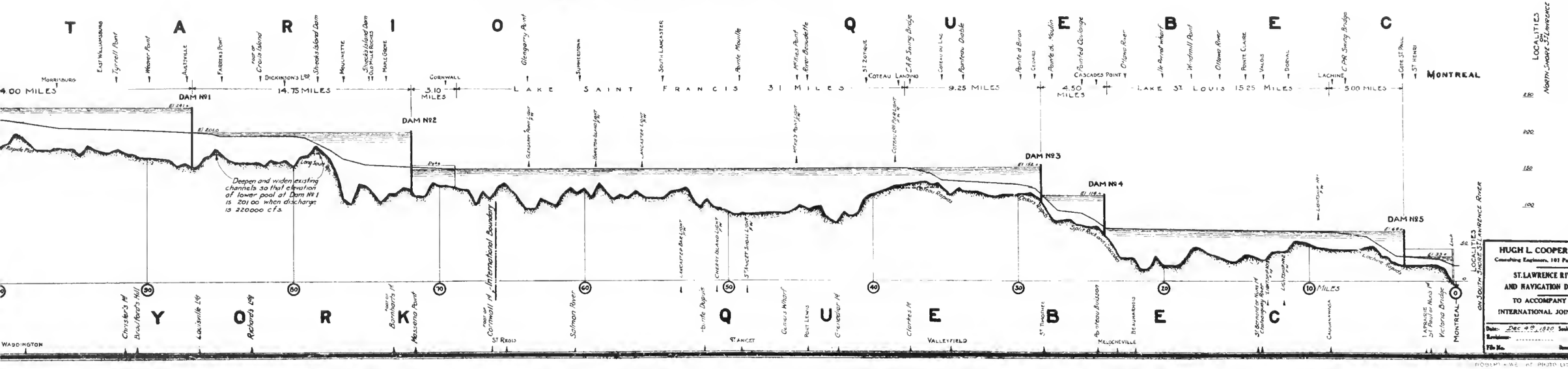
MINIMUM RECOMMENDED PROFILE OF ST LAWRENCE RIVER

BETWEEN LAKE ONTARIO LEVEL AT OGDENSBURG AND MONTREAL

DEVELOPED FOR

POWER & NAVIGATION PURPOSES.

Pool levels shown are approximate for a mean stage discharge of 220000 c.f.s.



HUGH L. COOPER & COMPANY
Consulting Engineers, 101 Park Avenue, New York

ST. LAWRENCE RIVER POWER AND NAVIGATION DEVELOPMENT, TO ACCOMPANY REPORT TO INTERNATIONAL JOINT COMMISSION.

Date: Dec 4th 1920 Scale: (Hor. 1" = 19800 ft. Vert. 1" = 30 ft.)
Revisions:
File No. Drawing No. 3468

PROSEMAKE AT PHOTO LITHO NEW YORK